# Guide to the Geology of Buffalo Rock and Matthiessen State Parks Area, La Salle County, Illinois

R.S. Nelson, D.H. Malone, R.J. Jacobson, and W.T. Frankie

Field Trip Guidebook 1996C September 28, 1996
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Department of Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY

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Natural Resources Building
615 E. Peabody Drive
Champaign, IL 61820-6964

**Cover photo** Dells area from the bridge showing the St. Peter Sandstone (photo by R.J. Jacobson).

**Geological Science Field Trips** The Educational Extension Unit of the Illinois State Geological Survey (ISGS) conducts four tours each year to acquaint the public with the rocks, mineral resources, and landscapes of various regions of the state and the geological processes that have led to their origin. Each trip is an all-day excursion through one or more Illinois counties. Frequent stops are made to explore interesting phenomena, explain the processes that shape our environment, discuss principles of earth science, and collect rocks and fossils. People of all ages and interests are welcome. The trips are especially helpful to teachers who prepare earth science units. Grade school students are welcome, but each must be accompanied by a parent or guardian. High school science classes should be supervised by at least one adult for each ten students.

A list of guidebooks of earlier field trips for planning class tours and private outings may be obtained by contacting the Educational Extension Unit, Illinois State Geological Survey, Natural Resources Building, 615 East Peabody Drive, Champaign, IL 61820. Telephone: (217) 244-2427 or 333-4747.

Three USGS 7.5-Minute Quadrangle Maps (La Salle, Starved Rock, and Tonica) provide coverage for this field trip area.

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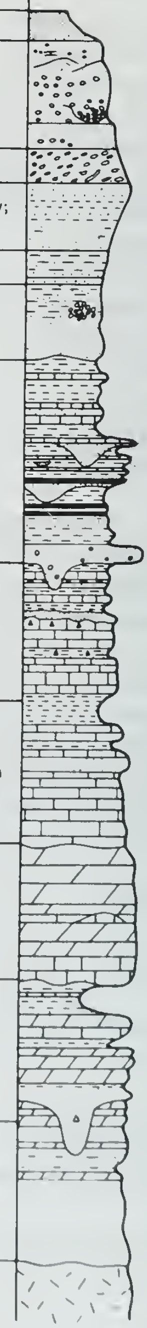
# CONTENTS

| Era | | Period or System and Thickness | Epoch | Age (years ago) | General Types of Rocks |
|---|---|---|---|---|---|
| CENOZOIC "Recent Life" | Age of Mammals | Quaternary 0–500' | Holocene | 10,000 | Recent—alluvium in river valleys |
| | | | Pleistocene Glacial Age | 1.6 m. | Glacial till, glacial outwash, gravel, sand, silt, lake deposits of clay and silt, loess and sand dunes; covers nearly all of state except northwest corner and southern tip |
| | | Tertiary 0–500' | Pliocene | 5.3 m. | Chert gravel, present in northern, southern, and western Illinois |
| | | | Eocene | 36.6 m. / 57.8 m. | Mostly micaceous sand with some silt and clay; present only in southern Illinois |
| | | | Paleocene | 66.4 m. | Mostly clay, little sand; present only in southern Illinois |
| MESOZOIC "Middle Life" | Age of Reptiles | Cretaceous 0–300' | | 144 m. | Mostly sand, some thin beds of clay and, locally, gravel; present only in southern Illinois |
| PALEOZOIC "Ancient Life" | Age of Amphibians and Early Plants | Pennsylvanian 0–3,000' ("Coal Measures") | | 286 m. / 320 m. | Largely shale and sandstone with beds of coal, limestone, and clay |
| | | Mississippian 0–3,500' | | 360 m. | Black and gray shale at base; middle zone of thick limestone that grades to siltstone, chert, and shale; upper zone of interbedded sandstone, shale, and limestone |
| | Age of Fishes | Devonian 0–1,500' | | 408 m. | Thick limestone, minor sandstones and shales; largely chert and cherty limestone in southern Illinois; black shale at top |
| | Age of Invertebrates | Silurian 0–1,000' | | 438 m. | Principally dolomite and limestone |
| | | Ordovician 500–2,000' | | 505 m. | Largely dolomite and limestone but contains sandstone, shale, and siltstone formations |
| | | Cambrian 1,500–3,000' | | 570 m. | Chiefly sandstones with some dolomite and shale, exposed only in small areas in north-central Illinois |
| | | Precambrian | | | Igneous and metamorphic rocks, known in Illinois only from deep wells |



Generalized geologic column showing succession of rocks in Illinois.

# BUFFALO ROCK AND MATTHIESSEN STATE PARKS AREA

The Buffalo Rock and Matthiessen State Parks area geological science field trip will acquaint you with the *geology**, landscape, and mineral resources for part of La Salle County, Illinois. Buffalo Rock State Park is located in north-central Illinois along the north bank of the Illinois River. It is approximately 85 miles southwest of Chicago, 140 miles northeast of Springfield, 240 miles northeast of East St. Louis, and 340 miles north of Cairo.

## GEOLOGIC FRAMEWORK

**Precambrian Era** Through several billion years of geologic time, La Salle County and surrounding areas have undergone many changes (see the generalized stratigrphic column, facing page). The oldest rocks beneath the field trip area belong to the ancient Precambrian *basement complex*. We know relatively little about these rocks from direct observations because they are not exposed at the surface anywhere in Illinois. Only about 35 drill holes have reached deep enough for geologists to collect samples from Precambrian rocks of Illinois. From these samples, however, we know that these ancient rocks consist mostly of granitic and rhyolitic igneous, and possibly *metamorphic*, crystalline rocks formed about 1.5 to 1.0 billion years ago. From about 1 billion to about 0.6 billion years ago, these Precambrian rocks were exposed at the surface. During this long period, the rocks were deeply weathered and eroded, and formed a landscape that was probably quite similar to that of the present Missouri Ozarks. We have no rock record in Illinois for the long interval of *weathering* and erosion that lasted from the time the Precambrian rocks were formed until the first Cambrian-age *sediments* accumulated, but that interval is almost as long as the time from the beginning of the Cambrian Period to the present.

Because geologists cannot see the Precambrian basement rocks in Illinois except as cuttings and cores from boreholes, they must use other various techniques, such as measurements of Earth's gravitational and magnetic fields, and seismic exploration, to map out the regional characteristics of the basement complex. The evidence indicates that in southernmost Illinois, near what is now the historic Kentucky–Illinois Fluorspar Mining District, *rift* valleys like those in east Africa formed as movement of crustal plates (plate *tectonics*) began to rip apart the Precambrian North American continent. These rift valleys in the midcontinent region are referred to as the Rough Creek Graben and the Reelfoot Rift (fig. 1).

**Paleozoic Era** After the beginning of the Paleozoic Era, about 520 million years ago in the late Cambrian Period, the rifting stopped and the hilly Precambrian landscape began to sink slowly on a broad regional scale, allowing the invasion of a shallow sea from the south and southwest. During the several hundred million years of the Paleozoic Era, the area that is now called the Illinois Basin continued to accumulate sediments deposited in the shallow seas that repeatedly covered it. The region continued to sink until at least 15,000 feet of sedimentary strata were deposited. At times during this era, the seas withdrew and deposits were weathered and eroded. As a result, there are some gaps in the sedimentary record in Illinois.

In the field trip area, bedrock strata range from more than 520 million years (the Cambrian *Period*) to less than 290 million years old (the Pennsylvanian Period). Figure 2 shows the succession of rock strata a drill bit would penetrate in this area if the rock record were complete and all the *formations* were present.

The elevation of the top of the Precambrian basement rocks within the field trip area ranges from 2,600 feet below sea level in northern La Salle County to 4,000 feet below sea level in southern La Salle County. The thickness of the Paleozoic sedimentary strata ranges from about 3,200 feet in northern La Salle County to about 4,600 feet in southern La Salle County.

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*Words in italics are defined in the glossary at the back of the guidebook. Also please note: although all present localities have only recently appeared within the geologic time frame, we use the present names of places and geologic features because they provide clear reference points for describing the ancient landscape.

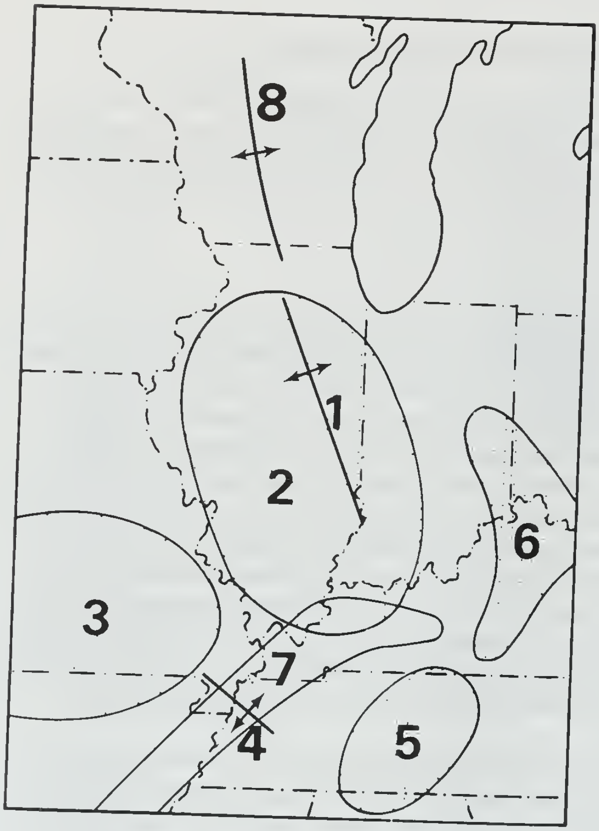



**Figure 1** Location of some of the major structures in the Illinois region. (1) La Salle Anticlinorium, (2) Illinois Basin, (3) Ozark Dome, (4) Pascola Arch, (5) Nashville Dome, (6) Cincinnati Arch, (7) Rough Creek Graben-Reelfoot Rift, and (8) Wisconsin Arch.

Pennsylvanian-age bedrock strata consisting of shale, siltstone, sandstone, limestone, coal, and underclay were deposited as sediments in shallow seas and swamps between about 320 and 286 million years ago. These rocks are exposed in the numerous limestone quarries, abandoned strip coal mines, clay pits, scattered roadcuts, and stream cuts. Pennsylvanian strata increase in total thickness from 0 feet in northern La Salle County, where the Pennsylvanian rocks have been removed by erosion, to more than 300 feet in southern La Salle County. (See *Depositional History of the Pennsylvanian Rocks* in the supplemental reading at the back of this guidebook for a more complete description of these rocks.)

## STRUCTURAL AND DEPOSITIONAL HISTORY

As noted previously, the Rough Creek Graben and the Reelfoot Rift (figs. 1 and 3) were formed by tectonic activity that began in the latter part of the Precambrian Era and continued until the Late Cambrian. Toward the end of the Cambrian, rifting ended and the whole region began to subside, allowing shallow seas to cover the land.

**Paleozoic and Mesozoic Eras** From the Late Cambrian to the end of the Paleozoic Era, sediments continued to accumulate in the shallow seas that repeatedly covered Illinois and adjacent states. These inland seas connected with the open ocean to the south during much of the Paleozoic, and the area that is now southern Illinois was like an embayment. The southern part of Illinois and adjacent parts of Indiana and Kentucky sank more rapidly than the areas to the north, allowing a greater thickness of sediment to accumulate. Earth's thin crust was periodically flexed and warped as stresses built up in places. These movements caused repeated invasions and withdrawals of the seas across the region. The former sea floors were thus periodically exposed to erosion, which removed some sediments from the rock record.

Many of the sedimentary units, called formations, have conformable contacts—that is, no significant interruption in deposition occurred as one formation was succeeded by another (figs. 2 and 4). In some

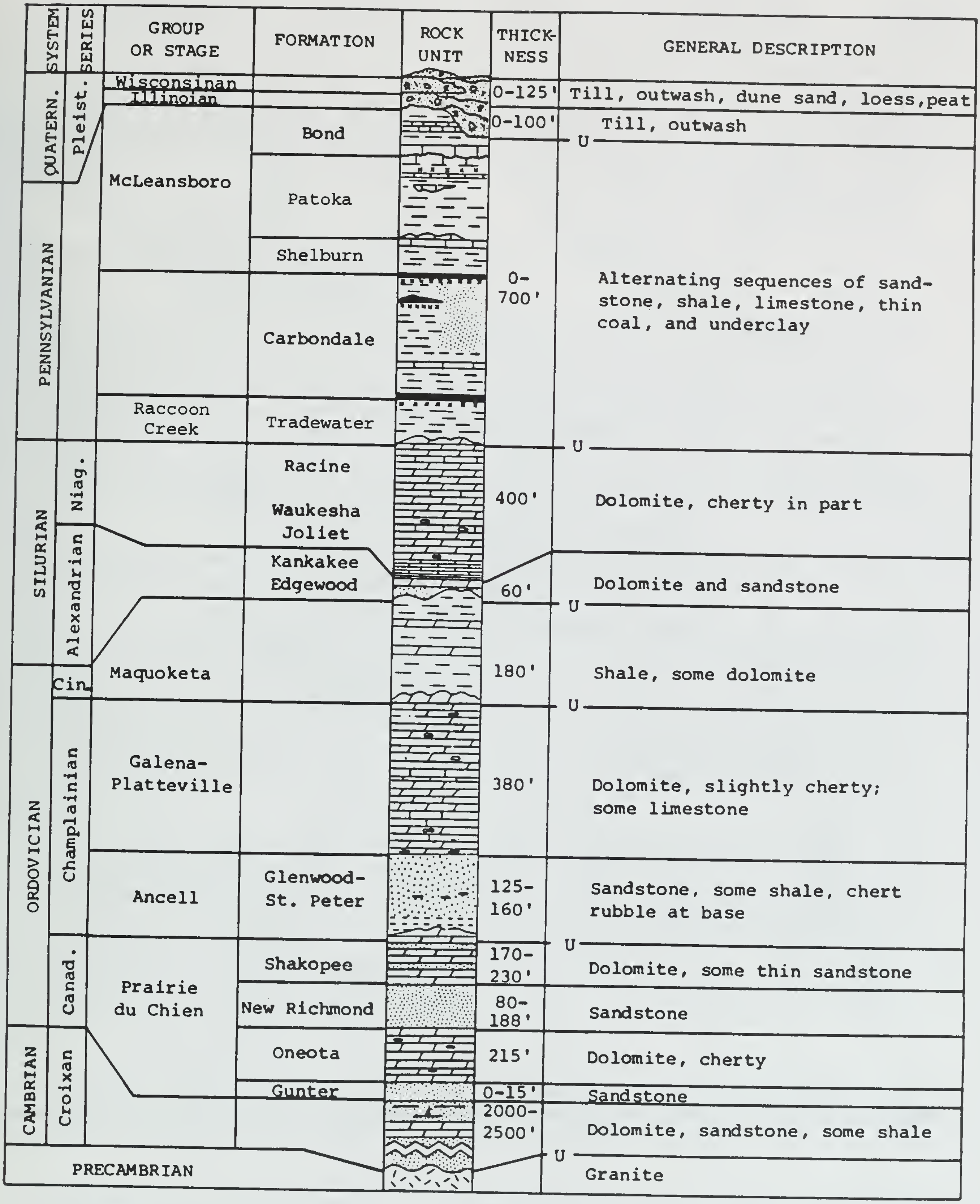



**Figure 2** Generalized stratigraphic column of the field trip area.

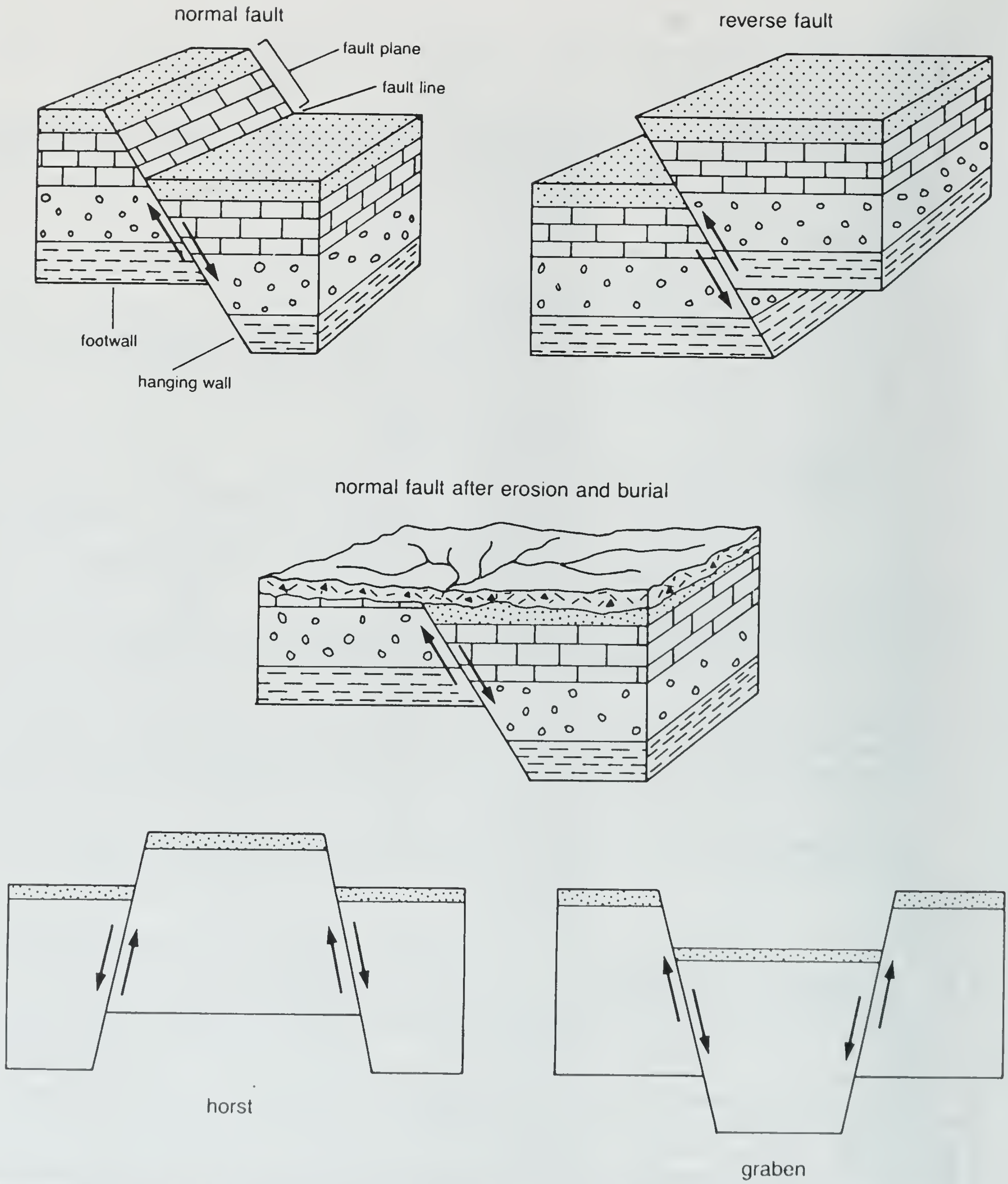
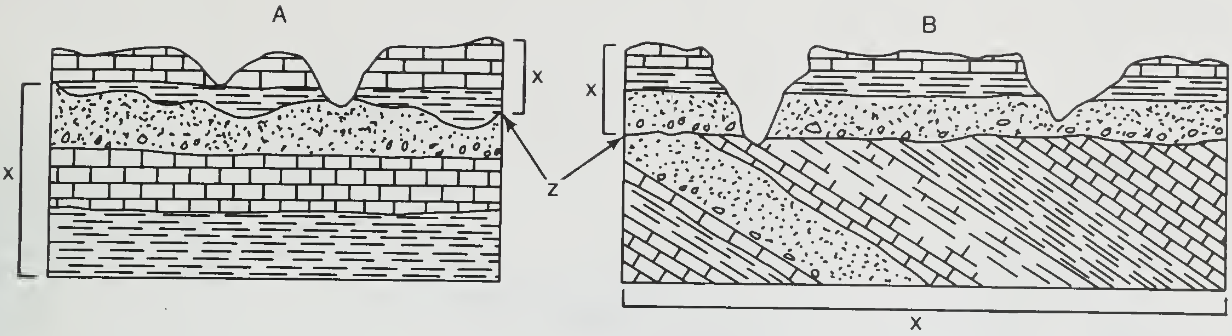



**Figure 3** Diagrammatic illustrations of fault types that may be present in the field trip area (arrows indicate relative directions of movement on each side of the fault).




A = disconformity

B = angular unconformity

**Figure 4** Schematic drawings of (A) a disconformity and (B) an angular unconformity (x represents the conformable rock sequence and z is the plane of unconformity).

instances, even though the composition and appearance of the rocks change significantly at the contact between two formations, the *fossils* in the rocks and the relationships between the rocks at the contact indicate that deposition was virtually continuous. In some places, however, the top of the lower formation was at least partially eroded before deposition of the next formation began. Fossils and other evidence in the two formations indicate that there is a significant age difference between the lower unit and the overlying unit. This type of contact is called an *unconformity* (fig. 4). If the beds above and below an unconformity are parallel, the unconformity is called a *disconformity*; if the lower beds have been tilted and eroded before the overlying beds were deposited, the contact is called an angular unconformity.

Unconformities are shown in the generalized stratigraphic column in figure 2 as wavy lines. Each unconformity represents an extended interval of time for which there is no rock record.

Near the close of the Mississippian Period, gentle arching of the rocks in eastern Illinois initiated the development of the La Salle Anticlinorium (figs. 1 and 5). This is a complex structure having smaller structures such as domes, *anticlines*, and *synclines* superimposed on the broad upwarp of the anticlinorium. Further gradual arching continued through the Pennsylvanian Period. Because the youngest Pennsylvanian strata are absent from the area of the anticlinorium (either because they were not deposited or because they were eroded), we cannot determine just when folding ceased—perhaps by the end of the Pennsylvanian or during the Permian Period a little later, near the close of the Paleozoic Era.

During the Mesozoic Era, which followed the Paleozoic Era, the rise of the Pascola Arch (fig. 1) in southeastern Missouri and western Tennessee formed the Illinois *Basin* by closing off the embayment and separating it from the open sea to the south. The Illinois Basin is a broad, subsided region covering much of Illinois, southwestern Indiana, and western Kentucky (fig. 1). Development of the Pascola Arch, in conjunction with the earlier sinking of deeper parts of the area to the north, gave the basin its present asymmetrical, spoon-shaped configuration (fig. 6). The geologic map (fig. 7) shows the distribution of the rock *systems* of the various geologic time periods as they would appear if all the glacial, windblown, and surface materials were removed.

The Buffalo Rock and Matthiessen State Parks field trip area straddles the La Salle Anticlinorium on the northern edge of the Illinois Basin. The La Salle Anticlinorium is more than 200 miles long and has as much as 2,500 feet of vertical relief. The anticlinorium is a complex uplift that consists of a large number of branching, sinuous monoclines, anticlines, and related domes.

Bedrock is exposed along the Illinois, Vermilion, and the Little Vermilion Rivers, and in the limestone and shale pits within the field trip area. The highest elevations of the bedrock occur along the crest of the La Salle Anticlinorium, 600 feet above sea level in central La Salle County. Because tilting of the bedrock layers took place several times during the Paleozoic Era, the dips of successive strata vary.


Figure 5 Structural features of Illinois (modified from Treworgy 1981).

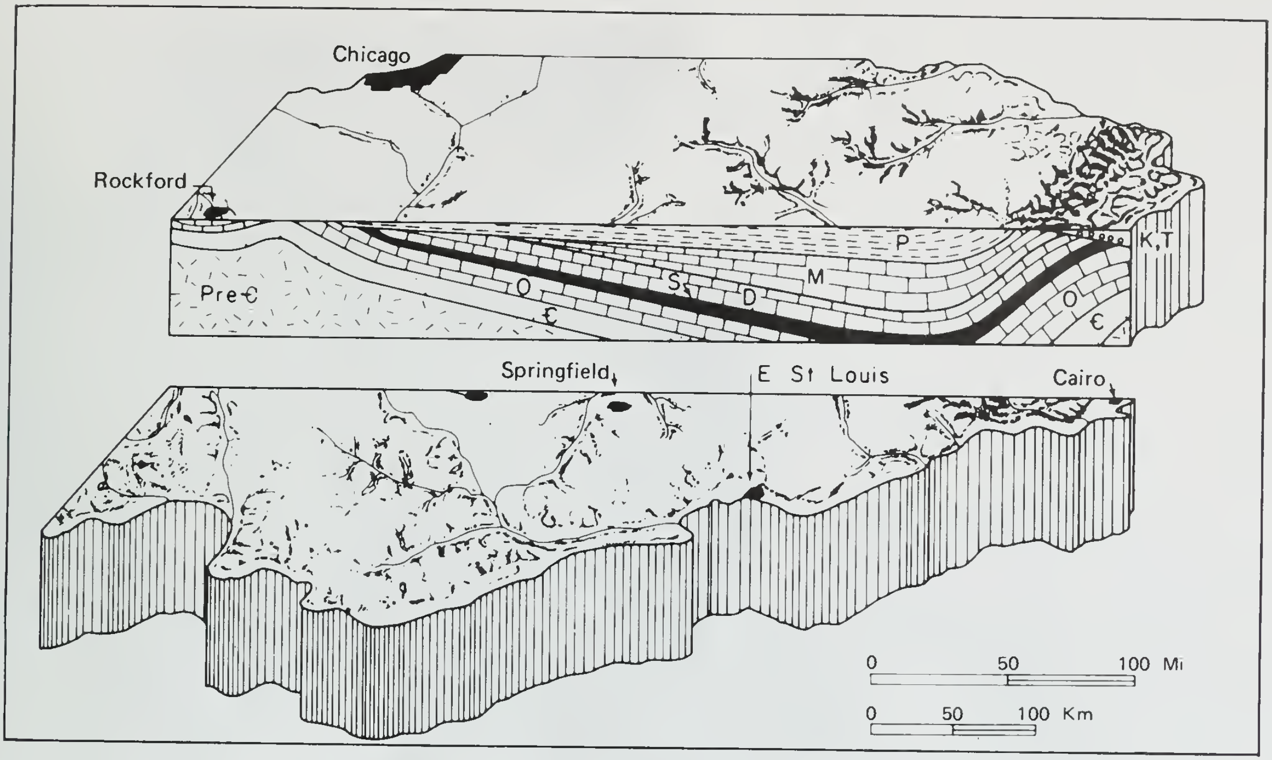



**Figure 6** Stylized north–south cross section shows the structure of the Illinois Basin. To show detail, the thickness of the sedimentary rocks has been greatly exaggerated and younger, unconsolidated surface deposits have been eliminated. The oldest rocks are Precambrian (Pre-Є) granites. They form a depression filled with layers of sedimentary rocks of various ages: Cambrian (Є), Ordovician (O), Silurian (S), Devonian (D), Mississippian (M), Pennsylvanian (P), Cretaceous (K), and Tertiary (T). Scale is approximate.

Younger rocks of the latest Pennsylvanian and perhaps the Permian (the youngest rock systems of the Paleozoic) may have at one time covered the area of La Salle County. It is possible that Mesozoic and Cenozoic rocks (see the generalized geologic column) could also have been present here. Indirect evidence, based on the stage of development (rank) of coal deposits and the generation and maturation of petroleum from source rocks (Damberger 1971), indicates that perhaps as much as 1.5 miles of latest Pennsylvanian and younger rocks once covered southern Illinois. During the more than 240 million years since the end of the Paleozoic Era (and before the onset of *glaciation* 1 to 2 million years ago), however, several thousands of feet of strata may have been eroded. Nearly all traces of any post-Pennsylvanian bedrock that may have been present in Illinois were removed. During this extended period of erosion, deep valleys were carved into the gently tilted bedrock formations (fig. 8). Later, the topographic relief was reduced by repeated advances and melting back of continental *glaciers* that scoured and scraped the bedrock surface. This glacial erosion affected all the formations exposed at the bedrock surface in Illinois. The final melting of the glaciers left behind the non-lithified deposits in which our Modern Soil has developed.

**Cenozoic Era: Glacial History** A brief general history of glaciation in North America and a description of the deposits commonly left by glaciers may be found in *Pleistocene Glaciations in Illinois* at the back of the guidebook.

Erosion that took place long before the glaciers advanced across the state left a network of deep valleys carved into the bedrock surface (fig. 8). Prior to glaciation, La Salle County was drained by an east–west ancient bedrock valley called the Ticona Channel. The Ticona bedrock valley lies just north of the Farm Ridge Moraine, on the southern edge of the field trip area. The Ticona Valley has been completely filled by glacial outwash from later glaciation, and the present Illinois River Valley was subsequently

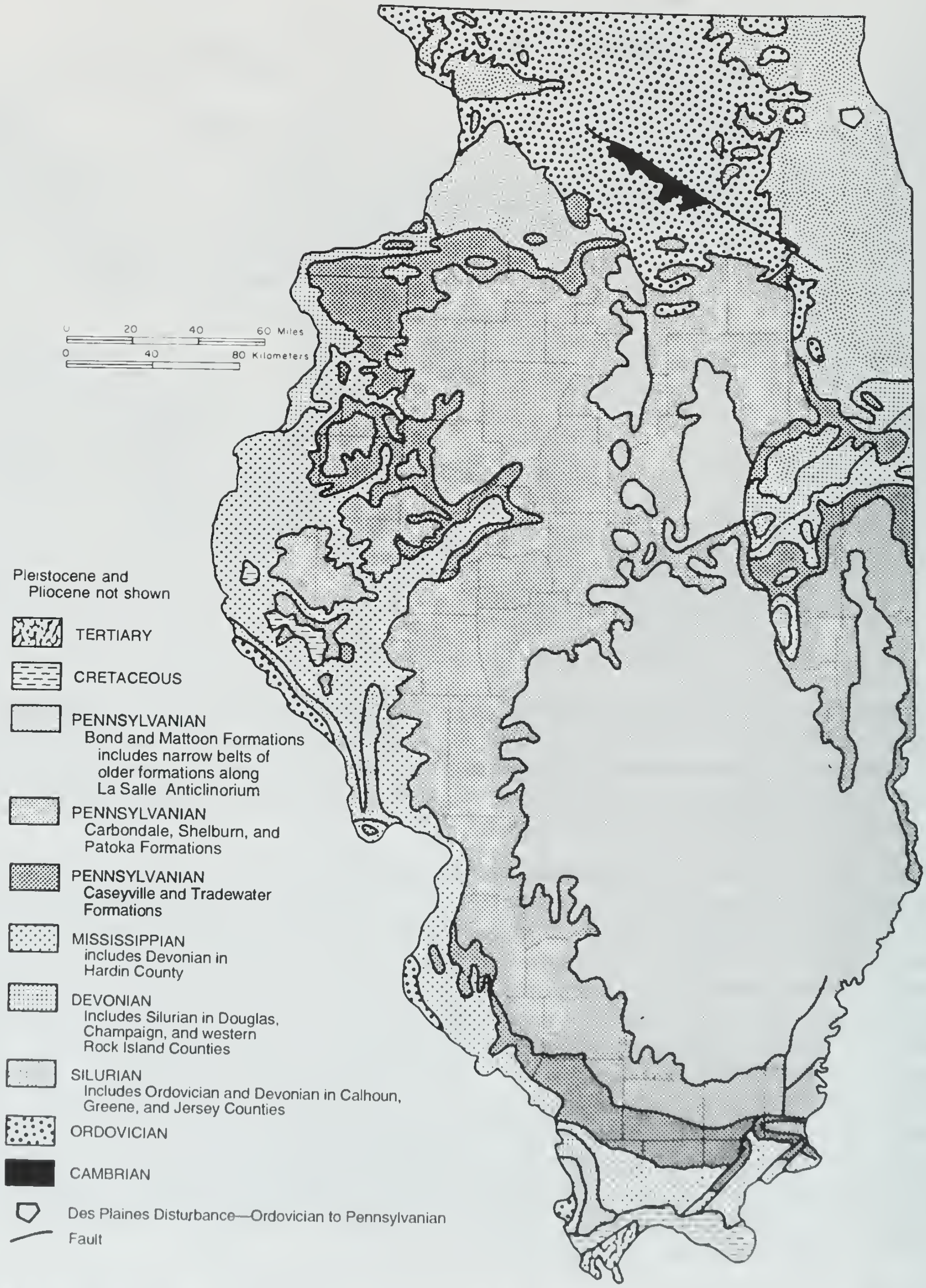



**Figure 7** Bedrock geology beneath surficial deposits in Illinois.

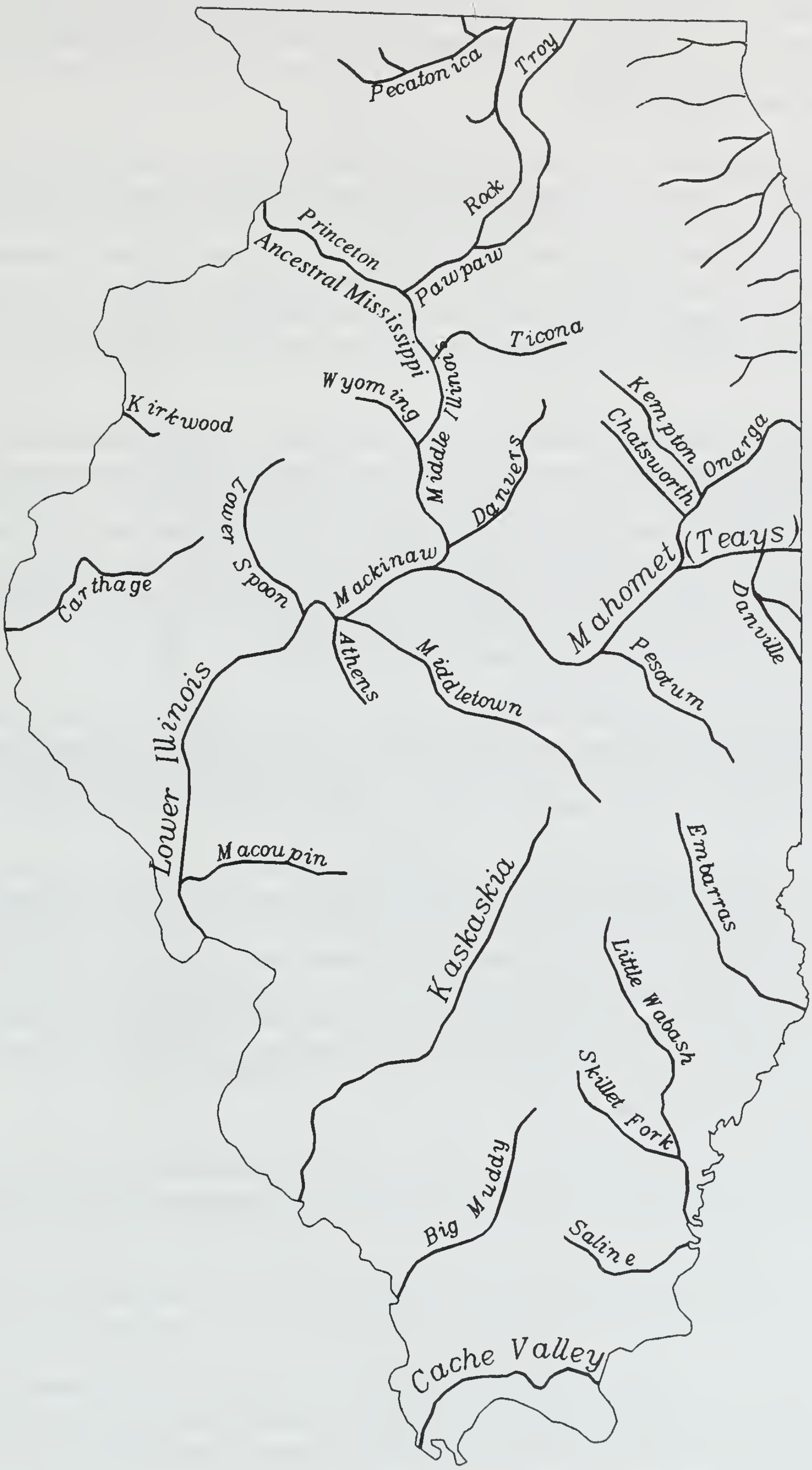



**Figure 8** Bedrock valleys of Illinois (modified from Bristol and Buschbach 1973).

formed by glacial meltwater that cut a new channel about 6 miles north and roughly parallel to the old Ticona Valley. It is of interest to note that most of the sediment that filled the Ticona Valley was sand and gravels. These sands and gravels serve as major aquifers for areas immediately surrounding the Ticona Valley. Because of the irregular bedrock surface and erosion, glacial *drift* is unevenly distributed across La Salle County.

During the Pleistocene *Epoch*, beginning about 1.6 million years ago, massive sheets of ice (called continental glaciers), thousands of feet thick, flowed slowly southward from Canada. The last of these glaciers melted from northeastern Illinois about 13,500 years before the present (B.P.). During the Illinoian glacial stage, which began around 300,000 years B.P., North American continental glaciers reached their southernmost position, approximately 290 miles south of here, in the northern part of Johnson County. The maximum thickness of the later Wisconsin Episode glacier was about 2,000 feet in the Lake Michigan Basin, but only about 700 feet over most of the Illinois land surface (Clark et al. 1988).

The *topography* of the bedrock surface throughout much of Illinois is largely hidden from view by glacial deposits except along the major streams. In many areas, the glacial drift is thick enough to completely mask the underlying bedrock surface. Studies of mine shafts, water-well logs, and other drill-hole information, in addition to scattered bedrock exposures in some stream valleys and roadcuts, show that the present land surface of this region does not reflect the underlying bedrock surface. The preglacial bedrock surface has been significantly modified and is subdued by glacial deposits. Moraines were deposited during the Woodfordian Substage, which began about 22,000 B.P. (See *Pleistocene Glaciations in Illinois* at the back of the guidebook).

Although Illinoian glaciers probably built morainic ridges similar to those of the later Wisconsinan glaciers, Illinoian moraines apparently were not so numerous and have been exposed to weathering and erosion for thousands of years longer than their younger Wisconsinan counterparts. For these same reasons, Illinoian glacial features generally are not as conspicuous as the younger Wisconsinan features.

Overlying the Wisconsin Episode deposits is a thin cover of deposits called the Peoria *Loess* (pronounced "luss"). These sediments, deposited as wind blown-silts during the Woodfordian Subage, which began about 22,000 years B.P., mantle the glacial drift throughout the field trip area. (See *Pleistocene Glaciations in Illinois* at the back of the guidebook.) Within La Salle County, the loess thins from 8 feet in the western half of the county to 4 feet in the eastern half, and is less than 2 feet within the Fox Valley drainage area. This fine grained dust, which covers most of Illinois outside the area of Wisconsinan glaciation, reaches thicknesses exceeding 15 feet east of the field trip area along the Mississippi and Illinois Rivers. Soils in this area have developed in the loess and the underlying weathered silty, clayey Wisconsin *till*.

Within the field trip area, glacial drift ranges in thickness from a few feet along the crest of the La Salle Anticlinorium to more than 200 feet, which corresponds with the location of the moraines.

## GEOMORPHOLOGY

**Physiography** The field trip area is located within the Bloomington Ridged Plain of the *Till Plains* Section of the Central Lowland Physiographic Province (fig. 9). The Bloomington Ridged Plain is characterized by low, broad morainal ridges of Woodfordian Age separated by wide, comparatively flat areas. Although the morainal ridges are conspicuous at a distance, their gentle distal (and locally proximal) slopes make them less obvious close at hand. Morainal topography is well preserved and only near major streams does the morainal topography give way to fluvial landforms. For a more complete description of glacial landforms see *Pleistocene Glaciations in Illinois* at the back of the guidebook.

According to Horberg (1950) and others (e.g., Leighton et al. 1948), an extensive lowland called the "central Illinois *peneplain*" had been eroded prior to glaciation into the relatively weak rocks of

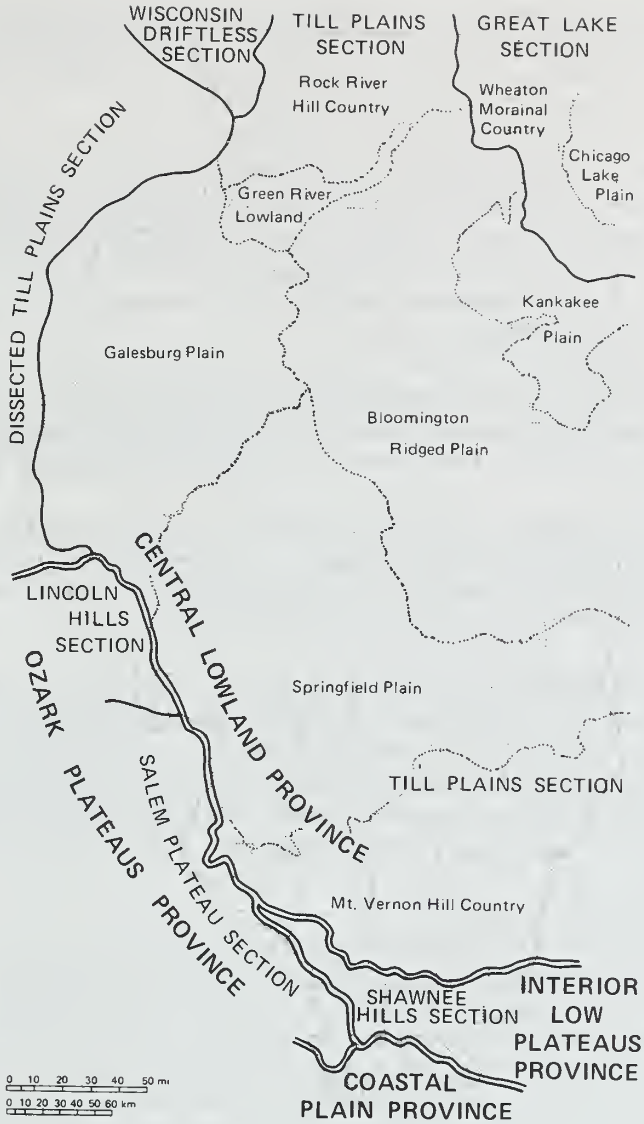



**Figure 9** Physiographic divisions of Illinois.

Pennsylvanian age east and south of the present-day Illinois River. Apparently, just before the advent of glaciation, an extensive system of *bedrock valleys* was deeply entrenched below the central lowland surface level. As glaciation began, streams probably changed from erosion to aggradation, that is, their channels began to build up and fill in because the streams did not have sufficient volumes of water to carry and move the increased volumes of sediment. To date, no evidence indicates that the early fills in these preglacial valleys were ever completely flushed out of their channels by succeeding deglaciation meltwater torrents.

**Bloomington Ridged Plain** The Bloomington Ridged Plain, according to Leighton et al. (1948), includes most of the Wisconsin moraines and is characterized by low, broad morainic ridges with intervening wide stretches of relatively flat or gently undulatory ground moraine. In many places the major moraines rise with gentle slopes; although they are conspicuous from a distance, the major moraines become less so near at hand, whereas the minor moraines are prominent locally. In this district more than in any other, the grass-covered stretches of rolling prairie and extensive swamps described by early settlers were most typically and extensively developed.

The glacial deposits are relatively thick throughout the district and completely conceal the bedrock topography, except locally. Illinoian and older drift are present below the Wisconsin in most places, so that the level aspect of present drift plains is due largely to the presence of the older drift sheets, which filled in and covered the irregularities of the bedrock surface.

Drainage is generally in the initial stages of development, and most streams follow and are eroding in constructional depressions, many of which cross morainic ridges. The valleys of principal streams are large, owing in part to the greater areal extent of this division and to its somewhat greater age, and have floodplains bordered by valley-train terraces. The Illinois River, the master-stream of the district, has a broad, flat-bottomed valley with steep walls and is bordered by numerous narrow steep-walled valleys with steep gradients.

**Drainage** Within the portion of La Salle County covered by this field trip, drainage is controlled by the Illinois River. The Vermilion River, located south of the Illinois River, and the Little Vermilion River, located north of the Illinois River, are major tributaries to the Illinois River within this area.

The rivers have incised through a relatively thin cover of unconsolidated materials overlying the La Salle Anticlinorium, and their drainage patterns are largely controlled by joint patterns associated with the La Salle Anticlinorium. Sedimentary rocks of Ordovician and Pennsylvanian age are exposed along the waterways throughout the field trip area.

**Relief** The highest land surface on the field trip route is between stop 6 and stop 7 along county road 2150 North, where the surface elevation is slightly more than 665 feet above mean sea level (msl). The lowest elevation is about 450 feet above msl along the Vermilion River at stop 4. The surface relief of the field trip area, calculated as the difference between the highest and lowest surfaces, is about 215 feet. *Local relief* is most pronounced along the Illinois River where the sandstone bluffs at Buffalo Rock State Park form a sheer vertical wall greater than 90 feet above the river.

## NATURAL RESOURCES

**Mineral production** Of the 102 counties in Illinois, 98 reported mineral production during 1992, the last year for which complete records are available. The total value of all minerals extracted, processed, and manufactured in Illinois during 1992 was $2,894,300,000, 0.5% lower than the 1991 total. Minerals extracted accounted for 90% of this total. Coal continued to be the leading commodity, accounting for 64% of the total, followed by industrial and construction materials at 21.4%, and oil at 14.2%. The remaining 0.4% included metals, peat, and gemstones. Illinois ranked 13th among the 31 oil-producing states in 1992 and 16th among the 50 states in total production of nonfuel minerals but continues to lead all other states in production of fluorspar, industrial sand, and tripoli.

La Salle County ranked 8th among all Illinois counties in 1992 on the basis of the value of all minerals extracted, processed, and manufactured. Economic minerals currently mined in La Salle County include industrial sand, stone, sand and gravel, and clay. La Salle County was the second leading producer of common clay. Common clay is defined as a clay or claylike material that is sufficiently plastic to permit ready molding. Common clays and shales mined in Illinois are used to manufacture bricks, draintiles, dinnerware, and cement. The average value per ton of common clay in Illinois in 1992 was $4.00.

Although no coal mines are currently active in La Salle County, cumulative production equals 65,547,638 tons. Coal has been mined from the Colchester, Herrin, and Danville Coals.

**Groundwater** Groundwater is a mineral resource frequently overlooked in assessments of an area's natural resource potential. The availability of this mineral resource is essential for orderly economic and community development. More than 35% of the state's 11.5 million citizens and 97% of those who live in rural areas depend on groundwater for their water supply. Groundwater is derived from underground

formations called aquifers. The water-yielding capacity of an aquifer can only be evaluated by constructing wells into it. After construction, the wells are pumped to determine the quality and quantity of groundwater available for use.

Because glacial deposits occur in this area, sand and gravel deposits are common throughout most of the county. However, most of these deposits are thin and do not yield vast amounts of water. The exception is in the vicinity of the Ticona bedrock valley, which contains thick deposits of unconsolidated materials that include thick sand and gravel zones. These sand and gravel deposits yield commercial amounts of water for industrial and municipal water supplies.

Throughout southern La Salle County, small municipal and farm water supplies are obtained from shallow Pennsylvanian formations. In most of La Salle County, water supplies have been obtained from the Silurian dolomites and the St. Peter Sandstone (Selkregg and Kempton 1958). In eastern La Salle County, the Galena-Platteville dolomite and the Prairie du Chien dolomites have supplied domestic water (Hackett and Bergstrom 1956).

## GUIDE TO THE ROUTE

Assemble in parking area of Buffalo Rock State Park (SW, Sec. 17, T33N, R3E, 3rd P.M., La Salle County, Starved Rock 7.5-minute Quadrangle).

***You must travel in the caravan.*** Please drive with headlights on while in the caravan. Drive safely but stay as close as you can to the car in front of you. Please obey all traffic signs. If the road crossing is protected by an Ilinois State Geological Survey (ISGS) vehicle with flashing lights and flags, please obey the signals of the ISGS staff directing traffic. When we stop, park as close as possible to the car in front of you and turn off your lights.

***Private property*** Some stops on the field trip are on private property. The owners have graciously given us permission to visit on the day of the field trip only. Please conduct yourselves as guests and obey all instructions from the trip leaders. So that we may be welcome to return on future field trips, follow these simple rules of courtesy:

- Do not litter the area.
- Do not climb on fences.
- Leave all gates as you found them.
- Treat *public* property as if you were the owner—which you are!

When using this booklet for another field trip with your students, a youth group, or family, remember that *you must get permission from property owners or their agents before entering private property.* No trespassing please.

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**STOP 1 West End of Original Buffalo Rock State Park** At this stop we will view the unconformity between the St. Peter Sandstone (Ordovician age) and the Colchester Coal and associated strata (Pennsylvanian age). We will also discuss the evolution of the upper Illinois River Valley, strip mining of coal, and mine reclamation. Because this is a State Park, PLEASE DO NOT HAMMER AT THIS STOP.

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| Miles to next point | Miles from start | |
|---|---|---|
| 0.0 | 0.0 | Begin road log at the entrance to Buffalo Rock State Park. Proceed left (west) on Dee Bennett Road. |
| 0.3 | 0.3 | Note the wetlands vegetation on the right. This plant community is dominated by cattails. |
| 0.2 | 0.5 | Note the spoil piles that form the ridge line to the right. These piles are the result of strip mining the Colchester Coal Member (Carbondale Formation). Between 1941 and 1948 the Osage Coal Company strip mined 820.4 acres of Colchester Coal. Unreclaimed mine spoil extends for 4 miles along the bluff. |
| 0.2 | 0.7 | Old quarry in the St. Peter Sandstone to the left. This is the quarry observed at stop 1. Numerous outcrops of St. Peter Sandstone are present along the leftside of the road. |
| 0.3 | 1.0 | Entrance to Starved Rock Yacht Club on the left. |
| 0.3 | 1.3 | Driving across Ottawa Terrace. |

**Ottawa Terrace** The Ottawa Terrace was cut on the St. Peter Sandstone by the Illinois River. Prior to construction of the Starved Rock Lock and Dam, the Ottawa Terrace stood about 20 feet above the river. The navigation pool has raised the river level, and this part of the Ottawa Terrace and Dee Bennett Road commonly floods.

| | | |
|---|---|---|
| 0.5 | 1.8 | Entrance to Western Yacht Club on the left. |
| 0.6 | 2.4 | Halfway house and Grand Village Site to the left. |

**Halfway house** The halfway house, also known as the Sulphur Springs Hotel, was originally built as a halfway house on the Chicago to Peoria stage line. It featured an elegant ballroom on the third floor and a sulfur spring spa in the basement. Abraham Lincoln was a regular guest here. The building is on the National Register of Historic Sites and is within the Illinois and Michigan Canal National Heritage Corridor.

**Grand Village Site (Zimmerman Site)** The Grand Village Site was occupied as early as A.D. 1 during the Late Woodland cultural era. In 1673 Louis Joliet and Father Jacques Marquette noted 74 lodges at this site. In 1674, Father Marquette established here the Mission of Immaculate Conception, which was the first mission in Illinois.

| | | |
|---|---|---|
| 0.9 | 3.3 | Entrance road to Starved Rock Lock and Dam on left. |

**Starved Rock Lock and Dam** This is one of eight navigation locks and dams on the Illinois and Des Plaines Rivers that allows commercial barge traffic to travel between Lake Michigan and the Mississippi River. The Corps of Engineers has the responsibility for maintaining a 9-foot-deep navigation channel. Dams are used to raise the river level, creating navigation pools. Locks are used to transfer barges and other traffic from one pool to the next. The State of Illinois began construction of the locks and dams in 1920. By 1929 the state had completed about two-thirds of the work, but had only 20% of the money needed to complete the project. The project was turned over to the Federal Government in 1930. The Illinois Waterway was completed and opened on June 22, 1933.

The dam is 1,280 feet long and consists of 10 taintor gates and 25 head gates along with associated piers. The taintor gates are 60 feet wide and 19 feet tall. The headgates are 14 feet wide and 16 feet tall. Both types of gates are under-flow gates that are raised or lowered to maintain desired flow in the river and navigation pool level. This is a single purpose dam that has no capacity to store water for flood control.

The lock is 110 feet wide and 600 feet long. Under normal conditions, there is a 17- to 19-foot difference between the upstream and downstream pools. The lock is used to transfer traffic from one pool to the other. The barge enters the lock, and the entry gates are closed. The water level is then raised or lowered to match the other pool. It takes 12 minutes to fill the lock and 9 minutes to empty it. Once the new pool level is achieved, the exit gate is opened and the barge moves out.

| | | |
|---|---|---|
| 0.1 | 3.4 | View of Starved Rock across the Illinois River. The large flag pole is located on top of Starved Rock. |
| 2.1 | 5.5 | Stop (2-way). TURN RIGHT (north) onto Illinois 178. Across Illinois 178 is the entrance road to the Utica Stone Company quarry where Shakopee Formation dolomite is quarried for aggregate. |
| 1.1 | 6.6 | Entering Utica, population 850. |
| 0.5 | 7.1 | Crossing the Illinois and Michigan Canal. The La Salle County Historical Society Building is on the north side of the canal, east of the road. |

**Illinois and Michigan Canal** Construction of the Illinois and Michigan Canal was begun in 1823 by the Illinois Canal Commission. The canal, completed in 1848 at a cost of $6.5 million, was 96 miles long, included 15 locks, and linked Chicago with La Salle. Freight was moved in individual wooden barges, pulled by mules or horses. The canal was closed in 1933 when the Illinois Waterway was opened.

| | | |
|---|---|---|
| 0.1 | 7.2 | STOP (4-way). LEFT TURN (west) onto Church Street (follow Illinois 178). |
| 0.1 | 7.3 | YIELD. RIGHT TURN (north) onto Division Street (follow Illinois 178). |
| 0.05 | 7.35 | Crossing active railroad tracks. Look both ways for trains before crossing. |
| 0.15 | 7.5 | Crossing Clark Run. St. Peter Sandstone crops out to the right along the creek. |
| 0.1 | 7.6 | LEFT TURN (west) onto Richard Hallett Road (2853 North) and ascend hill. |
| 0.8 | 8.4 | Road curves to the right (north). |
| 0.5 | 8.9 | STOP (1-way). LEFT TURN (west) onto US Route 6. |
| 0.5 | 9.4 | Crossing Pecumsaugon Creek. |

**Black Ball Mine** The Black Ball Mine is located at the mouth of Pecumsaugon Creek where the creek feeds the Illinois and Michigan Canal. Beginning about 1869, lime was mined here to make hydraulic cement, which was used to repair and restore locks along the canal. The cement was in demand for a variety of other uses and was asked for by name because of the high quality of the raw materials and special kilns used to make the cement.

The mine is part of a closed nature preserve. The only access to the mine and workings is by guided tour between May 1 and September 1. Contact Judy Schaulmberger at Buffalo Rock State Park (815-433-2220) for information about tours.

| | | |
|---|---|---|
| 0.3 | 9.7 | Road curves left (south). |
| 0.4 | 10.1 | Road curves right (southwest). |
| 0.4 | 10.5 | Entrance to La Salle Speedway on the left. |
| 0.4 | 10.9 | St. Peter Sandstone crops out on the right. |
| 0.3 | 11.2 | T.B. Amusement Park (water park) on the left. |
| 0.2 | 11.4 | Entrance ramp to Interstate 39. CONTINUE AHEAD. |
| 0.1 | 11.5 | East abutment of US Route 6 bridge over Interstate 39. |
| 0.2 | 11.7 | West abutment of US Route 6 bridge over Interstate 39. Prepare to turn right. |
| 0.1 | 11.8 | RIGHT TURN onto East Fifth Road (to Troy Grove). Prepare to turn left. |
| 0.05 | 11.85 | LEFT TURN to "Historical Rockwell Cemetery, originated 1836." |
| 0.2 | 12.05 | RIGHT TURN into Illinois Cement Company Quarry. |

**STOP 2 Illinois Cement Company Quarry** At this stop you can examine the La Salle Limestone and associated strata (Pennsylvanian age) and observe changes in the nature of the limestone associated with the La Salle Anticlinorium. You can also collect a variety of types of limestone and several types of marine invertebrate fossils. We will discuss the nature of the La Salle Anticlinorium, the La Salle Limestone, mining methods, and the making of cement.

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| | | |
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| 0.0 | 12.05 | Leave stop 2. LEFT TURN (southwest) onto cemetery road. |
| 0.2 | 12.25 | TURN RIGHT (south) onto East Fifth Road. |
| 0.05 | 12.3 | LEFT TURN (northeast) onto US Route 6, prepare to turn right onto Interstate 39 (south). |
| 0.01 | 12.4 | TURN RIGHT onto Interstate 39 South. The original Alpha Cement Company quarry is across the highway at ten o'clock. |
| 0.4 | 12.8 | Cross over conveyor belt that carries limestone from quarry to the cement plant. |
| 0.1 | 12.9 | North abutment of the Abraham Lincoln Bridge over Illinois River, crossing over railroad tracks. |

**Abraham Lincoln Bridge** The Abraham Lincoln Bridge is reported to be the longest bridge in the state. The original Abraham Lincoln Bridge is about 0.5 mile to the west. The Interstate bridge was named the Abraham Lincoln Bridge to preserve the title of the longest bridge.

| | | |
|---|---|---|
| 0.3 | 13.2 | Main channel of the Illinois River. |
| 0.1 | 13.3 | Spoil pile from the La Salle County Carbon Coal Company, Jones No. 1 Mine at ten o'clock. |

**La Salle County Carbon Coal Company, Jones No. 1 Mine** The La Salle County Carbon Coal Company Jones No. 1 Mine opened in 1886 and closed in 1928. The mine was 440 feet deep and encountered three coal seams: 36 inches of Danville Coal at 217 feet, 48 inches of Springfield Coal at 276 feet, and 40 inches of Colchester Coal at 436 feet.

| | | |
|---|---|---|
| 0.9 | 14.2 | South abutment of the Abraham Lincoln Bridge. Prepare to exit to Interstate. |
| 0.8 | 15.0 | EXIT Interstate 39 at Oglesby Exit (Exit 54). |
| 0.3 | 15.3 | RIGHT TURN (west) onto North 25. |
| 0.6 | 15.9 | RIGHT TURN (north) onto Alonso Smith Road. |
| 0.9 | 16.8 | South entrance to Illinois Valley Community College on the left. |
| 0.2 | 17.0 | STOP (4-way). Main entrance to Illinois Valley Community College. |
| 0.2 | 17.2 | Descend south wall of the Illinois River Valley. |
| 0.3 | 17.5 | Road cut on the right. |

**Limestone strata** Strata from below the La Salle Limestone to above the Little Vermilion Limestone are exposed in this road cut and the bluff above the road cut. This exposure is near the western limit of the La Salle Limestone, and here the unit is relatively thin and contains several clay beds. The upper bench of the limestone is the same layer as at the northwest corner of the Illinois Cement Company Quarry, and it contains large, well preserved *brachiopod* fossils.

| | | |
|---|---|---|
| 0.1 | 17.6 | STOP (1-way). RIGHT TURN (east) onto Illinois 351 and Illinois 71. |
| 0.3 | 17.9 | Crossing under Interstate 39. |
| 0.3 | 18.2 | Crossing over abandoned railroad on bridge. |
| 0.1 | 18.3 | Entering the Village of Jonesville. Prepare to veer left. |
| 0.2 | 18.5 | VEER LEFT (east). Continue on Illinois 71. |
| 0.2 | 18.7 | West abutment of bridge over Vermilion River. La Salle Limestone crops out along river. |
| 0.15 | 18.85 | East abutment of Vermilion River Bridge. |
| 0.05 | 18.9 | Weathered, highly breciated La Salle Limestone crops out on both sides of the road. |
| 0.2 | 19.1 | Active quarry (Lone Star Industries pit no. 3) in La Salle Limestone on right. |
| 0.7 | 19.8 | Road curves right (south). |
| 0.2 | 20.0 | Road curves left (east). Entrance to pit no. 3 runs straight ahead (south) from this curve. |

**Pit no. 3** Pit no. 3, currently being mined by Lone Star Industries for cement, has evolved over time. Originally, pit no. 3 consisted of a narrow strip roughly parallel to the Vermilion River and was separated from the river by 100 to 200 feet of unmined limestone. Leheigh Cement Company wanted to preserve the scenic nature of the river. The eastward limit of mining in pit no. 3 was controlled by the thickness of overburden. Prior to the mid-1970s, only 10 to 20 feet of overburden was removed to get to the limestone. In the mid-1980s, Lone Star Industries acquired the Leheigh Cement Company and determined that several tens of feet of overburden could be removed economically. Mining of pit no. 3 resumed and is expanding eastward. The overburden removed includes the Little Vermilion Limestone. The overburden is used as fill in reclaiming the quarry. The original pit no. 3 has been totally reclaimed.

| | | |
|---|---|---|
| 0.6 | 20.6 | Oglesby Road to the right. |
| 0.4 | 21.0 | Entrance road to Matthiesen Lake on the right. |
| 1.0 | 22.0 | STOP (4-way). LEFT TURN (north) onto Illinois 178. |
| 0.5 | 22.5 | RIGHT TURN into Starved Rock Clay Products Pit (second entrance) stay on right and park in grass. Stop 3. |

**STOP 3 Starved Rock Clay Products Clay Pit** At this stop you will observe the Colchester Coal and associated strata in a disconformable relationship with the St. Peter Sandstone and Platteville Dolomite. You will also see reworked sandstone and have the opportunity to collect coal, pyrite, chert-agate, and petrified wood.

| | | |
|---|---|---|
| 0.0 | 22.5 | Leave stop 3. TURN LEFT (south) onto Illinois 178. |
| 0.5 | 23.0 | STOP (4 way): intersection with Illinois 71. CONTINUE AHEAD. |
| 1.0 | 24.0 | TURN RIGHT (west). Entrance to Matthiessen State Park, Dells Area. Stop 4. |

**STOP 4 Matthiessen State Park, Dells Area** Meet at the shelter, west of the parking area, for orientation and introduction of personnel who will be stationed at various locations in the park. After orientation and introductions, you may eat lunch at your leisure. Geologists will be stationed at six locations (upper bridge, Giant Bath Tub, base of stairs at the lower bridge, sandstone cave area at the base of the water fall, deformed Platteville Formation, and mouth of the creek at the Vermilion River) to explain the geology. There are approximately 200 stairs (not in continuous runs) from the bottom of the canyon to the shelter and parking lot.

| | | |
|---|---|---|
| 0.0 | 24.0 | Depart stop 4: RIGHT TURN (south) onto Illinois 178. |
| 0.85 | 24.85 | Entrance to Matthiessen State Park River, River Overlook Area on the right. Much of the Carbondale Formation (Pennsylvanian age) is exposed as discontinuous outcrops along the bluff in the overlook area. |
| 1.1 | 25.95 | The skyline at two o'clock consists of a mature deciduous forest developed on the Vermilionville Sandstone (Carbondale Formation). |
| 0.45 | 26.4 | TURN RIGHT. Entrance to the Moline Consumers Company Vermilion Quarry. Stop 5. |

**STOP 5 Moline Consumers Company, Vermilion Quarry** At this stop you will observe the Platteville Dolomite (Ordovician age) and some of the associated structures of the La Salle Anticlinorium (dipping beds and faults). You will also have the opportunity to collect limestone-dolomite, chert, calcite, pyrite, and a variety of marine invertebrate fossils.

If you are departing the field trip route at this stop, you may (1) follow the rest of the road log to stop 8 (mile 31.9) and follow directions given there, or (2) turn left onto Illinois 178. Interstate 80 is 6.5 miles to the north, through the town of Uttica.

| | | |
|---|---|---|
| 0.0 | 26.4 | Depart stop 5. RIGHT TURN (south) onto Illinois 178. |
| 0.2 | 26.6 | La Salle County Road 8 on left. Road to Vermilionville. CONTINUE AHEAD. |
| 0.15 | 26.75 | TURN RIGHT on Road 2249. |

**STOP 6 North Bank of the Vermilion River** This is part of the Wildcat Rapids on the Vermilion River. Here you will observe a discontinuity in the Platteville Formation. This discontinuity is probably a bentonite bed representing an Ordovician-age ash fall event associated with an explosive volcanic eruption similar to the one at Mt. St. Helens in Washington. The discontinuity is offset by several inches by vertical faults. Pennsylvanian-age sediments are preserved in a channel cut into the Platteville Formation. PLEASE DO NOT HAMMER ON THE CHANNEL DEPOSITS.

| | | |
|---|---|---|
| 0.0 | 26.75 | Depart stop 6. RIGHT TURN (south) onto Illinois 178. |
| 0.3 | 27.1 | North abutment of bridge over the Vermilion River. |
| 0.1 | 27.2 | South abutment of bridge over the Vermilion River. |
| 0.3 | 27.5 | Entering the village of Lowell |
| 0.2 | 27.7 | TURN RIGHT (west) onto Ed Lambert Road, La Salle County 14 (North 2101). |
| 0.4 | 28.1 | Road curves left (southwest). |
| 0.4 | 28.5 | TURN RIGHT (west) onto 2150. House with the swimming pool is on the right. |
| 0.1 | 28.6 | Begin gravel road. |
| 0.4 | 29.0 | STOP (1-way). TURN RIGHT (north) onto East 675. Resume paved road. |
| 0.9 | 29.9 | Stop 7. Access path to stop 7 is behind the blue gate in the Department of Natural Resources Nature Preserve. |

**STOP 7 Cyclothems in the Carbondale Formation** This cut bank on the Vermilion River exposes the top of the Tradewater Formation and all of the Carbondale Formation. The exposure is located approximately 0.5 mile to the east of the road; access is by foot, along the path. Some impressions and carbonized remains of soft bodied marine invertebrates have been collected from the Francis Creek Shale at this site.

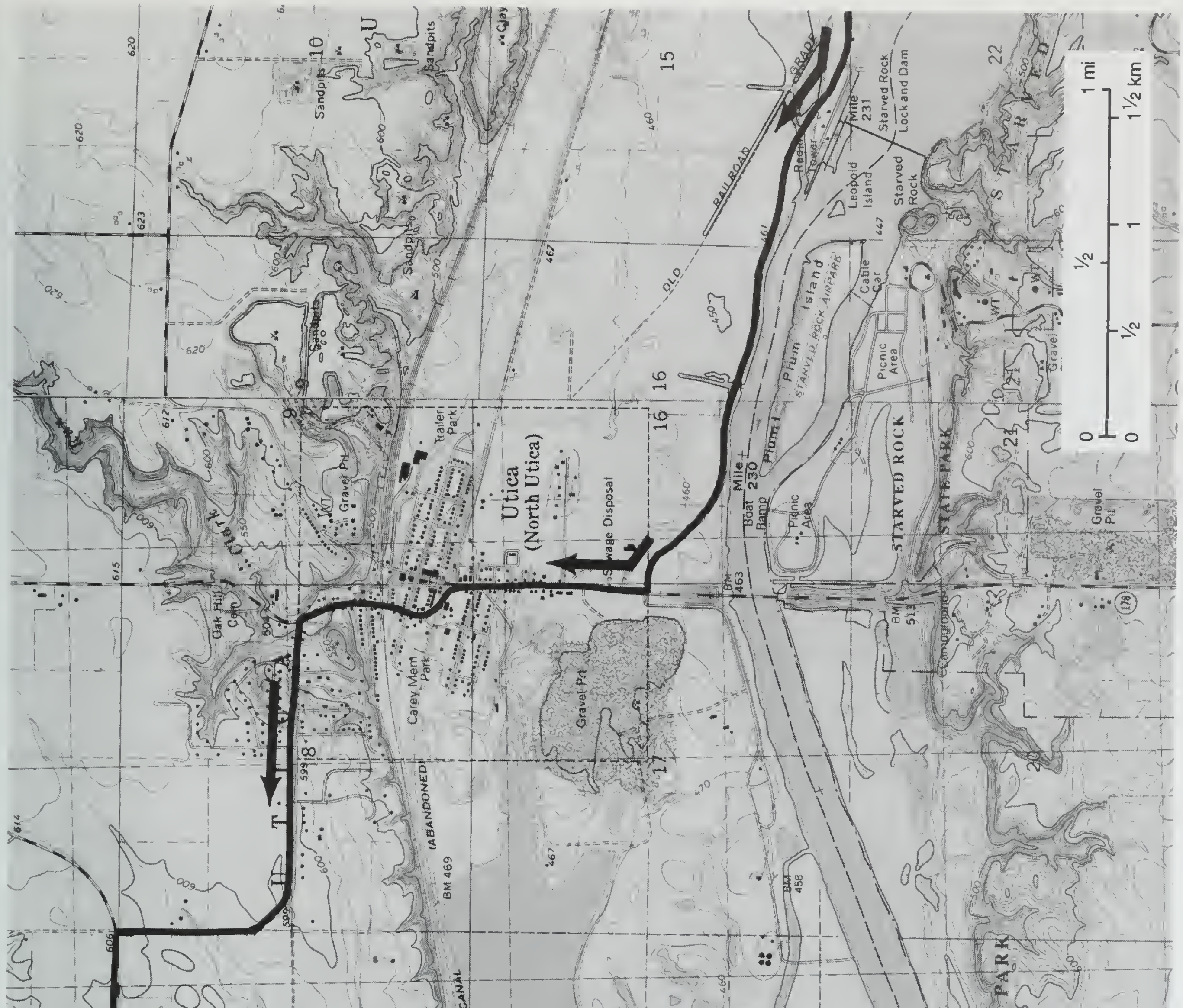
| | | |
|---|---|---|
| 0.0 | 29.9 | Depart stop 7. CONTINUE AHEAD (north). |
| 0.4 | 30.3 | Begin gravel road. Entering Lonestar Industries Bailey Falls Quarry (discontinued operation). |
| 0.3 | 30.6 | LEFT TURN (west). Straight ahead is the access road to Bailey Falls and the quarry. |
| 0.9 | 31.5 | Crossing bridge over abandoned railroad tracks. |
| 0.1 | 31.6 | Crossing Bailey Creek. Stop 8 is visible to the right between one and two o'clock. |
| 0.3 | 31.9 | Stop 8. |

**STOP 8 Quaternary Strata Exposed in the Highwall of the Bailey Falls Quarry** At this stop you will observe and examine glacial, fluvial, and aeolian (wind-blown) deposits that provide clues to part of the Quaternary history of the area. These materials are exposed on steep and sometimes unstable slopes. USE EXTREME CAUTION WHEN EXAMINING THESE EXPOSURES.

End of road log

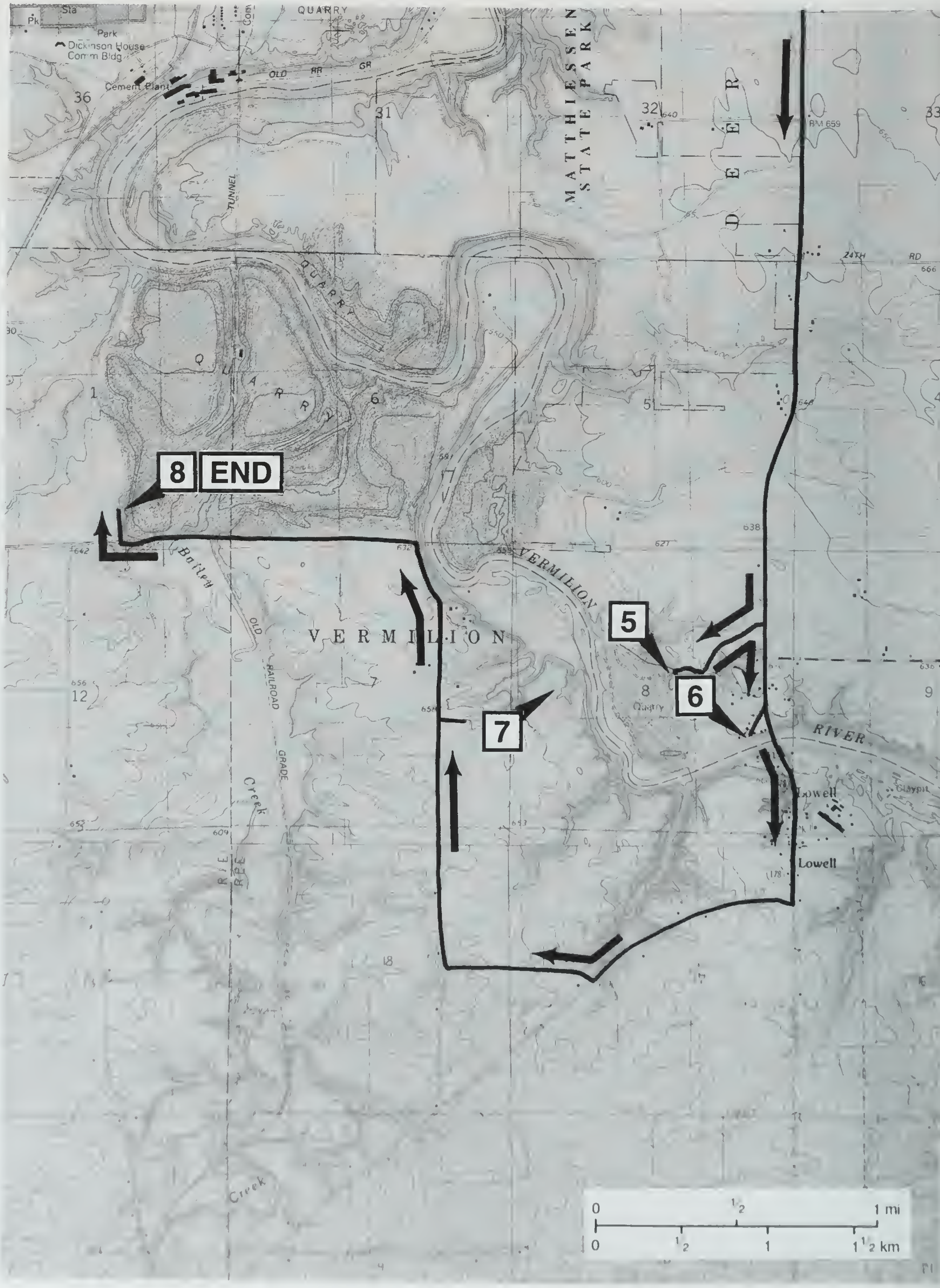
Leave stop 8. CONTINUE AHEAD until 1-way stop at US Route 251. Interstate 39 interchange 51 is 0.5 miles west on Illinois Routes 351 and 71. Interchange 52 is 0.75 miles north on Illinois Route 251. Interstate 80 is 7 miles to the north on Interstate 39.

START
1
ILLINOIS
RIVER
BUFFALO ROCK STATE PARK
STARVED ROCK STATE PARK
Delbridge Island
ELEVATION 459
Mile 235
Sulphur Well
Salt Well
Cave of the Winds
Sheehan
Sew Disposal Pond
Cem
County Home
OLD ROCK ISLAND RAILROAD GRADE
ABANDONED CANAL
Ravine
O T T A W
U T I C A
0 1/2 1 mi
0 1/2 1 1 1/2 km


Utica
(North Utica)
Trailer Park
Sewage Disposal
Carey Mem Park
Gravel Pit
Oak Hill Cem
(ABANDONED)
MICHIGAN
AND
CANAL
ILLINOIS
LaSalle Speedway
Forest Lawn Memorial Park
29TH
ROAD
Lake
RIVER
Plum Island
Plum I
STARVED ROCK AIRPARK
Leopold Island
Starved Rock
Starved Rock Lock and Dam
Mile 231
Mile 230
Radio Tower
OLD
RAILROAD
GRADE
Boat Ramp
Picnic Area
Cable Car
STARVED ROCK
STATE PARK
STARVED ROCK STATE PARK
Campground
Sandpits
Gravel Pit
0
1/2
1 mi
0
1/2
1
1 1/2 km


2
Matthiessen Sch
Water Tank
Northwest Sch
Hegeler Park
Lincoln Sch
St Hyacinth Sch
Park
Water Tank
Jackson Sch
Fire Sta
LA SALLE
City Hall
Sewage Disposal
RIVER
Quarry
Oakwood Cem
Rockwell Cem
INTERCHANGE 57
Quarry
Forest Lawn Memorial Park
LaSalle Speedway
Pecumsaugan
MICHIGAN
AND
ILLINOIS
Split Rock Lake
L A S A L L E
ILLINOIS
RIVER
STARVED ROC
Lake
Mile 225
Boat Ramp
Mine Dump
Jonesville
Trailer Park
Piety Hill
VERMILLION
RAILROAD
RIVER
QUARRY
Illinois Valley Community College
Radio Towers (WLPO & WAJK)
ROAD
INTERCHANGE 54
Lincoln Sch
Sewage Disposal
Oglesby
Substation
0
1/2
1 mi
0
1/2
1
1 1/2 km


3
4
LUNCH
STARVED ROCK STATE PARK
MATTHIESSEN STATE PARK
DEER PARK
Deer Park Country Club
Lehigh Memorial Park
Gravel Pit
QUARRY
VERMILION RIVER
OLD RAILROAD GRADE
Oglesby
Sewage Disposal
Park
Fire Sta
Dickinson House Comm Bldg
Cement Plant
Conveyor
TUNNEL
0 ½ 1 mi
0 ½ 1 1½ km


QUARRY
Park
Dickinson House
Comm Bldg
Cement Plant
MATTHIESSEN STATE PARK
DEER
24TH RD
TUNNEL
QUARRY
QUARRY
8
END
5
6
7
VERMILION
VERMILION
RIVER
Bailey Creek
OLD RAILROAD GRADE
Quarry
Lowell
Lowell
Claypit
0
1/2
1 mi
0
1/2
1
1 1/2 km

## STOP DESCRIPTIONS

**STOP 1 Buffalo Rock State Park** (NE, SE, SE, Sec. 18, T33N, R3E, La Salle County, Starved Rock 7.5-minute Quadrangle)

Buffalo Rock is a large, steep-sided monolith, rising 100 to 120 feet above the floodplain of the Illinois River. The monolith is elongate (1.2 miles long by 0.3 miles wide) and is oriented parallel to the Illinois River Valley. The top of Buffalo Rock is about the same elevation as the bluffs on either side of the river.

**Development of the Illinois River and the Origin of Buffalo Rock**
Before glaciers advanced into the midwest, the topography and drainage system was much different from today's. Then, there were three main drainage basins in the region. Northeastern Illinois, eastern Wisconsin, and western lower Michigan drained north through the Lake Michigan Lowland. Western Wisconsin, eastern Minnesota, northeastern Iowa, and northwestern Illinois drained south through the Ancestral Mississippi River (fig. 8). Portions of Ohio, Indiana, and central Illinois drained westward through the Teays (Mahomet) River (fig. 8). In Illinois, the Ancestral Mississippi River flowed southeastward from near Cordova to near Hennepin and then southward until it joined the Teays River System in southeastern Tazewell County. The combined river then drained southwestward along the present course of the Lower Illinois River.

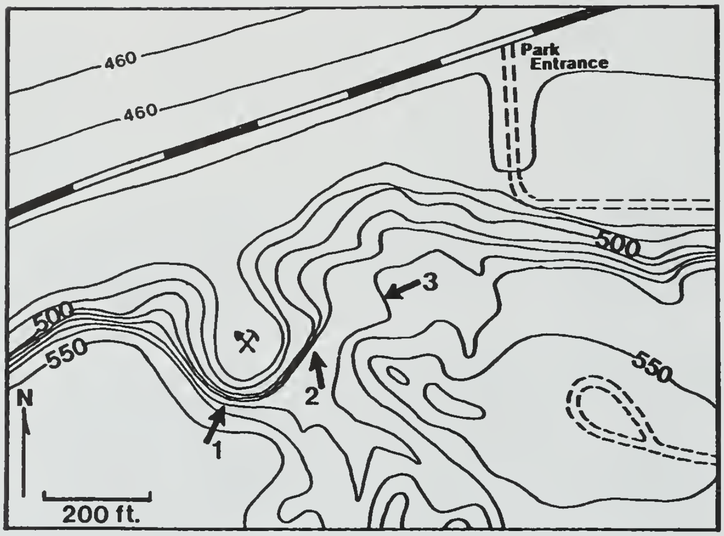
In La Salle County, the crest of the La Salle Anticlinorium formed a low discontinuous ridge that acted as a local drainage divide. West of this ridge, short, steep streams drained to the west, into the Ancestral Mississippi River. East of the ridge, long streams with gentle *gradients* flowed south-southeast and drained into the Teays (fig. 8).

Although the region was subjected to several pre-Wisconsinan glaciations, these glaciations did little to modify the general drainage patterns. (See *Pleistocene Glaciations of Illinois* in back of this guideook).

The Late Wisconsinan (Woodfordian) glacial episode (see *Pleistocene Glaciations*) caused significant changes in the drainage pattern of the midwest. Major ice lobes advanced westward out of the Lake Erie Lowland and south out of the Lake Michigan Lowland into Illinois. Where these lobes of ice converged, lobate *moraines* were formed. An early consequence of this glacial advance was the damming of the southward-flowing Ancestral Mississippi River, forming a series of lakes filled by glacial meltwater and streamflow. As each lake basin filled, it overflowed into the next basin downstream. Ultimately, this process established the present course of the Mississippi River between Cordova, Illinois, and Muscatine, Iowa.

The back-melting of ice lobes also formed a series of short-lived lakes filled with meltwater trapped between the morainal ridges and the retreating ice front. As each moraine was overtopped and breached by rising meltwater, vast amounts of water were released in a torrent. These torrents rapidly cut new channels and ripped sediments out of some pre-existing channels. The course of the Upper Illinois River (upstream from Henepin) was formed by a series of these torrents.

In La Salle County, the first of these torrents coursing down the Upper Illinois River rapidly cut a valley about 1 mile wide and a few tens of feet deep. The top of Buffalo Rock (Buffalo Rock Terrace at an elevation of about 540 feet) marks the floor of the initial channel. Later, even more spectacular torrents incised more than 100 feet deeper into bedrock. It is possible that the deeper incision may have been produced by the rapid retreat of a spectacular falls or steep cascade that formed where the torrent was cutting through relatively resistant strata. Waterfalls in Starved Rock State Park and at other locations along the Illinois River may still mark the retreat (headward erosion) of the falls or cascades




1) Outcrop of the Ordovician-Pennsylvanian unconformity.
2) Pyrite nodules on stripped surface.
3) Selenite crystals.

**Figure 10** Map of a portion of Buffalo Rock State Park .

up tributary streams. Buffalo Rock may have been left as an island during the fall's retreat, much like Goat Island will be left as a monolith in the Niagara River as the American Falls (at Niagara, New York) retreat along the east side of the island and the Horseshoe Falls (Canadian Falls) retreat along the west side of the island.

### Geology of Buffalo Rock

At Buffalo Rock (fig. 10), the Colchester Coal Member of the Carbondale Formation and its underclay (Pennsylvanian, fig. 11) rest directly on St. Peter Sandstone (Ordovician, fig. 12) (figs. 13, 14, and 15). This unconformity represents a time gap in the stratigraphic succession of about 170 million years and erosion (or nondeposition) of more that 1,100 feet of strata. This thickness estimate is based on the known thickness of strata between the Colchester Coal and the top of the St. Peter Sandstone in a deep well at Lostant, about 14 miles to the southwest, and the 1,250 to 1,300 feet of strata between the Colchester Coal and the St. Peter Sandstone found elsewhere in western Illinois. The Colchester (fig. 13) was the first coal to extensively blanket northern and western Illinois. Prior to its deposition, the distribution and thickness of older Pennsylvanian sediments was strongly influenced by the hills and valleys that had been eroded in the pre-Pennsylvanain bedrock surface.

**Colchester Coal Member** The Colchester Coal (figs. 11 and 13) at Buffalo Rock averages 22 inches thick. Elsewhere in La Salle County, the coal is slightly more than 2 feet thick. The Buffalo Rock Coal Company strip mined the portion of Buffalo Rock in Section 19, about three-quarters of the top of the rock. The portion of Buffalo Rock in Section 18 was never mined, and the area (43 acres) was given to the state for a park in 1928 by Richard T. Crane, Jr.

**TABLE 1** Analysis of Colchester Coal

| ISGS Lab # | | Proximate Analysis | | | Ultimate Analysis | | | | | | | | Heating Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Sulfur Content | | | | |
| | Moisture Content | Volatile Matter | Fixed Carbon | Ash | Hydrogen | Carbon | Nitrogen | Oxygen | Sulfate | Pyrite | Organic | Total | BTUs |
| C-2306 | 12 | 40.6 | 39.7 | 7.7 | 5.99 | 61.8 | 0.93 | 17.6 | 0.04 | 3.52 | 2.44 | 6 | 6,410 |
| | | | | | | | | | | | | | |
| C-2309 | 14.2 | 36.2 | 39.5 | 10.1 | 5.74 | 57.9 | 0.99 | 18.2 | 0.08 | 5.59 | 1.48 | 7.15 | 5,989 |

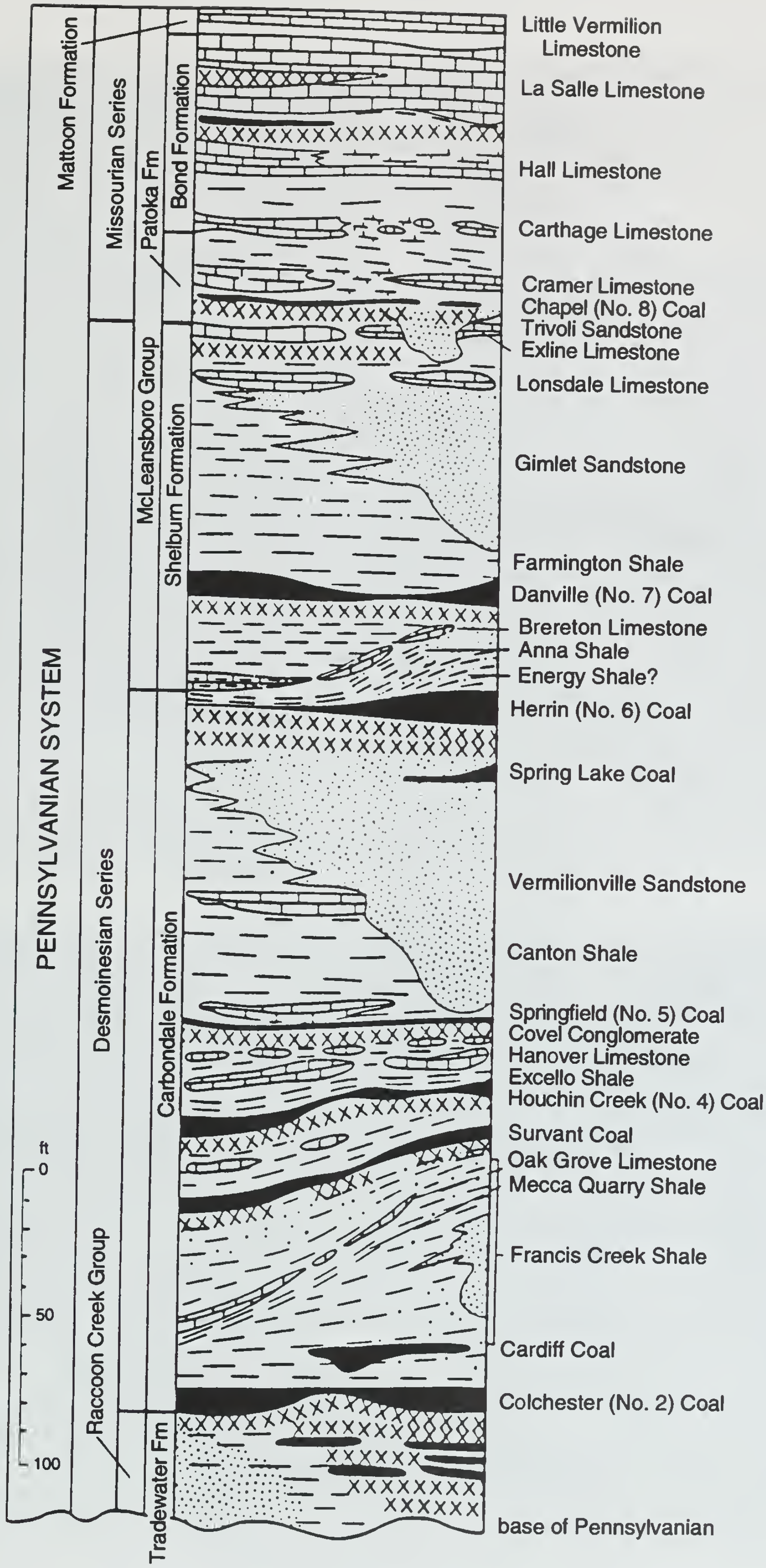
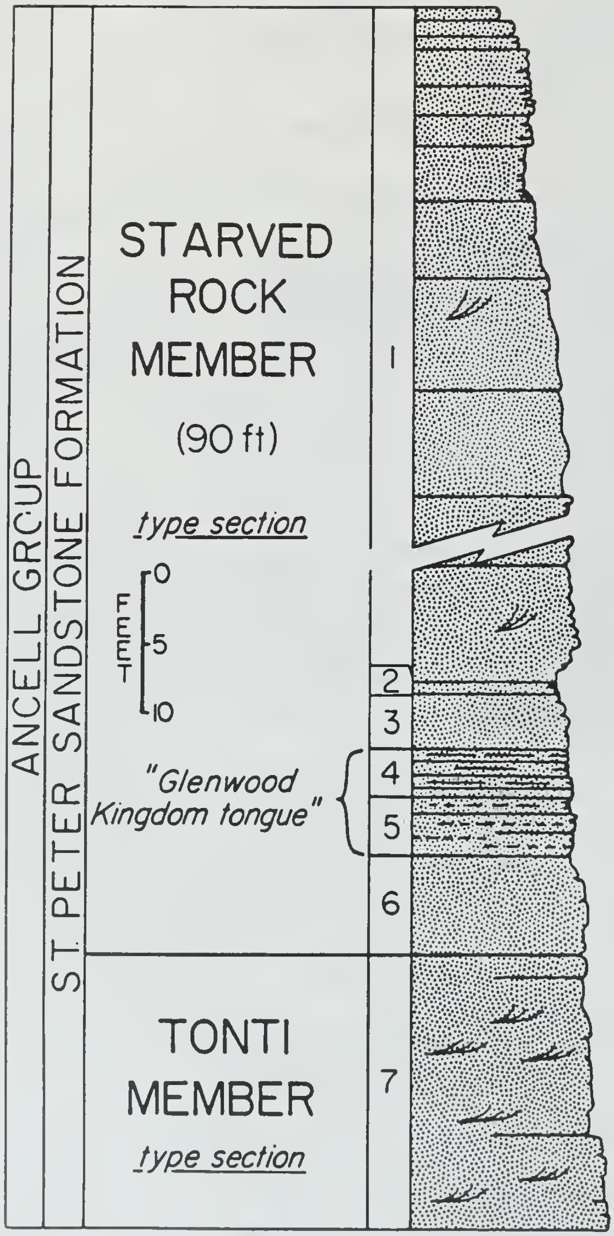



**Figure 11** Generalized stratigraphic column of Pennsylvanian rocks in La Salle and Livingston Counties (modified from Jacobson 1985).




1. Sandstone - light brown to white, consists of medium-size well rounded quartz grains, well sorted, thick-bedded.

2. Sandstone - white, silty, consists of fine well rounded quartz grains, friable.

3. Sandstone - gray, consists of medium-size quartz grains, well sorted, massive.

4. Sandstone - light brown to white, bimodal in texture, consisting of both fine and coarse well rounded quartz grains (Glenwood texture), argillaceous, thin-bedded.

5. Sandstone - light brown to white, consists of well rounded very fine to medium quartz grains, friable, silty streaks.

6. Sandstone - light brown to white, consists of medium well rounded quartz grains, friable, well sorted.

7. Sandstone - light brown to white, consists of fine well rounded quartz grains, friable, well sorted, thick-bedded, commonly cross-bedded. Base concealed below water.

**Figure 12** Stratigraphic column illustrating the St. Peter Sandstone.

**St. Peter Sandstone** The St. Peter Sandstone (fig. 14) is of special interest geologically because of its widespread occurrence and remarkably high purity. The St. Peter occurs throughout an area of the upper Midwest that stretches from northern Michigan to Kentucky and from Kansas to Ohio. The principal areas of its exposure in Illinois are in the Dixon-Oregon area and the Ottawa-La Salle area, where the rocks of Middle Ordovician age are folded and brought to the bedrock surface along the flanks of the Oregon Anticlinorium, the Ashton Arch, and the La Salle Anticlinorium. The St. Peter Sandstone forms high bluffs along the Illinois River (such as at Starved Rock State Park), and Starved Rock itself presents a north-facing cliff approximately 125 feet high (fig. 14). Elsewhere in Illinois, the unit has been penetrated in the subsurface by many wells. Except locally where it has been removed by erosion, the formation underlies almost the entire state.

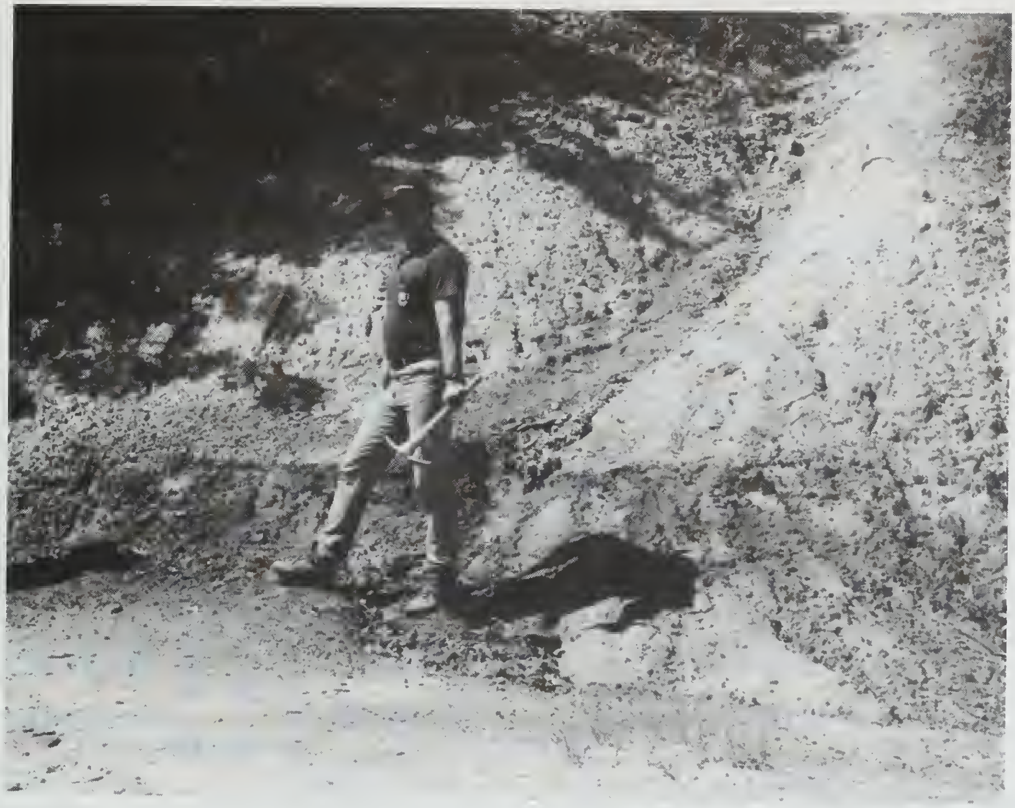


**Figure 13** Basal Pennsylvanian sediments at stop 1. R.S. Nelson is standing on top of the unconformity surface on the St. Peter Sandstone. Top of Colchester Coal is at Dr. Nelson's right knee and is overlain by gray Francis Creek Shale (photo by W.T. Frankie).

**Figure 14** St. Peter Sandstone in the quarry wall with overlying Pennsylvanian shales and claystone, (photo by W.T. Frankie).


**Figure 15** Pyrite crystals in upper unconformity surface on St. Peter Sandstone at stop 1, (photo by W.T. Frankie).

The St. Peter is a remarkably pure, fine grained sandstone consisting of well rounded grains of quartz. Under a microscope, many of the grains exhibit a peculiar frosted or dull appearance. At many exposures the rock is light gray to pure white, but commonly it is slightly brownish in color because of staining by iron oxide. The sandstone also exhibits well developed, inclined laminations called cross-bedding. The rock exhibits a sugary texture and is typically *friable* and soft, and is easily disaggregated in the hand. In the subsurface, the St. Peter is sometimes tightly cemented by calcium carbonate, suggesting that its loose texture at the surface has been produced by the removal of cement by weathering and by leaching by percolating groundwater.

The origin of the St. Peter Sandstone has interested geologists for decades. An early theory suggested that the sandstone was deposited on land in a vast interior desert of drifting dune sand. Similar cross-bedding, roundness, and frosting are found in sands of present-day deserts, such as the Great Sahara Desert of North Africa. The rounding and frosting is caused by the grains' striking and abrading each other as they are moved along by the wind. Today most geologists accept evidence indicating that the St. Peter Sandstone formed in a marine environment. All of the properties of the sandstone can also be explained as the products of wave and current action in a shallow sea. In addition, beds of marine limestone are present in the middle and upper parts of the formation in extreme northern and southwestern Illinois, Iowa, Arkansas, and Oklahoma. Marine fossils occur in some of the limestone beds and—although extremely rarely—in the sandstone as well. Evidence that the sand was extensively churned and mixed by burrowing, sediment-feeding organisms (bioturbation) has been observed at some localities in Missouri.

The sand grains that make up the St. Peter were derived principally from the weathering and erosion (reworking) of pre-existing sandstones. The ultimate origin of the quartz grains was probably the Precambrian igneous and metamorphic rocks exposed in south-central Canada. The reworked sand grains were transported southward by streams into the Middle Ordovician sea about 480 million years ago. Conditions in the sea remained very stable for a long time, and the sand deposits were extensively reworked by waves and currents that wore away the less resistant mineral grains and winnowed out the finer muddy particles, leaving behind the well sorted, highly resistant quartz sand. As the quartz

grains were moved along the sea bottom by currents and washed back and forth by waves, they gradually became rounded. The cross-bedding in the St. Peter Sandstone also indicates a high-energy, agitated environment and more strongly resembles cross-bedding exhibited by known marine sandstones than that found in dune sandstones. Some shifting of the St. Peter sands probably occurred in dunes along the shoreline of the St. Peter sea, similar to that occurring along present-day shorelines such as Padre Island or Indiana Dunes. These dune sands were later eroded and incorporated into the marine deposits as the seashore advanced toward the north.

The contact between the St. Peter Sandstone and the older sedimentary rocks upon which it rests is another major unconformity or erosion surface like the one that underlies the Pennsylvanian rocks. After deposition of the Lower Ordovician strata, crustal movements raised the midcontinent region above sea level, and along the interval of erosion (about 15 million years), accompanied by widespread devlopment of solution features (karst topography), cut deeply into the rocks exposed at the surface. There is evidence that a river system drained across northern Illinois from the northeast and cut deep channels into the bedrock surface. In northern Illinois and southern Wisconsin, the lower Ordovician strata were completely removed from the flanks of the Wisconsin Arch in many places. The erosion interval ended in the Middle Ordovician when the midcontinent region was lowered below sea level again and the ocean again spread over the region. The clean, well sorted sand that became the St. Peter Sandstone was deposited on the erosion surface where Lower Ordovician and Cambrian rocks were exposed. The St. Peter is generally less than 200 feet thick, but where the sand filled ancient river channels, it is locally as much as 500 feet thick.

The St. Peter Sandstone has been mined for a long time for silica sand. Silica sand has many uses ranging from sand blasting to making glass. Several active St. Peter Sandstone quarries are in the area, and abandoned St. Peter Sandstone quarries are present on the north side of Buffalo Rock (figs. 10 and 14) and between Buffalo Rock and the Illinois and Michigan Canal. Old underground St. Peter Sandstone mines are present along the base of the bluffs north of Buffalo Rock.

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**STOP 2 Illinois Cement Company Quarry** (NW, Sect. 11, T33N, R1E, La Salle County, La Salle 7.5-minute Quadrangle)

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The Illinois Cement Company quarries the La Salle Limestone (Pennsylvanian) (fig. 11) as a major ingredient for making Portland cement. The quarry is expanding northward. Overburden above the limestone is removed by scrapers and placed in the portion of the quarry undergoing restoration (to the south). In this manner, more than one square mile of limestone has been mined and the land subsequently restored.

Once the limestone has been uncovered, numerous drill holes are bored to the base of the limestone. The drill holes are then charged with explosive. Because of the proximity to houses, the Illinois Cement Company uses several small blasts to break the limestone, rather than fewer larger blasts. The broken limestone is loaded into large trucks and taken to the conveyor belt loader. The limestone is then transported over 1 mile by conveyor belt to the cement plant.

**Making Cement**

Who first discovered how to make cement is unkown, but it may have been discovered when heat from a campfire dehydrated blocks of gypsum and limestone used to make the hearth. If these rocks are placed in a firepit and heated, the rock surfaces dehydrate and produce a fine powder that can fall between the stones. If a light rain then soaks into the powder, the stones cohere to produce a primitive masonary. Forms of such a gypsum cement were used by early Egyptians. Greeks and Romans improved on the Egyptian cement by burning limestone (calcined limestone). Early mortars consisted of *calcined* lime, sand, and water. Various types of sands were used. Calcined lime, volcanic ash, and water also made an excellent mortar. Gravel, broken rock, or broken tile was incorporated to

make concrete for pavement and walls. Between 1756 and 1830, at least six investigators independently discovered that a superior cement can be produced if the limestone and clay are burned so hot that the mixture almost melts. The resulting clinker is then crushed to make cement. The relative amounts of lime and clay control many of the cement properties. Joseph Aspdin patented a product which he named *Portland Cement* (British Patent 5,022, December 18, 1824). The process of making cement has undergone numerous improvements since 1824.

**Limestone**

Before we examine the La Salle Limestone at this stop, we will briefly review the origin of carbonate rocks.

The vast majority of sedimentary rocks, mainly sandstones, shales, and conglomerates, are fragmented or “clastic” rocks. They consist of fragments of pre-existing rocks that were weathered out and transported as “clasts” by water, wind, or ice from their place of origin and deposited at some distant site. Limestones and dolomites, called carbonate rocks because they contain large amounts of calcium carbonate ($CaCO_3$), form much differently from clastic rocks. The components of carbonate rocks are disssolved in water and transported in solution from their source to their depositional site in the ocean. These dissolved components are eventually extracted from the ocean water by biological or chemical processes. Biological processes are by far the more important of the two because organisms with hard parts became abundant about 540 million years ago. Many organisms, mainly shelly invertebrates, extract dissolved materials from seawater for the manufacture of shells. This skeletal material is eventually incorporated into the rock record as limestone or dolomite. In other words, to quote Noel P. James, “Carbonates are born, not made.” Unlike terrigenous (deposited on land) rocks, the components of carbonate rocks are formed very near the ultimate site of deposition rather than at some distant source.

Rates of carbonate growth and production are tied to narrow ranges of temperature, pressure, light, nutrients, and terrigenous input. Marine environments where light is abundant (usually shallower than a few hundred feet in depth), the water is warm, and the polluting terrigenous input is minimal are usually dominated by the deposition of carbonate rocks. Thus clear tropical seas are the optimum sites for the carbonate factory to prosper. Places where carbonate sedimentation is occurring today include the Florida Keys, Florida Bay, the Bahama Platform, and the South China Sea. At present, carbonate deposition is occurring at a much slower rate than it has in the geologic past. During the early and middle Paleozoic, carbonates were the dominant sedimentary deposits in North America. Their deposition can be attributed to the favorable tropical latitude of the North American plate and abundant shallow marine environments during this time.

**Importance of Limestones and Dolomites** Carbonate rocks are rich with information about earth history. Their components yield important clues about the physical, chemical, and biological conditions of the environments of deposition. Because carbonate rocks contain fossils, they are integral to the study of the evolution of life. Economically, because carbonate rocks are often very porous, they may contain significant accumulations of hydrocarbons or abundant amounts of useable groundwater. Many of the world's lead deposits are formed in carbonate rocks. Both the Missouri lead belt and the deposits in southwest Wisconsin and northwest Illinois are in Ordovician dolomites.

Limestone and clay are important components for manufacturing cement. Many limestone units also are quarried for use as building stone or road aggregate. Crushed limestone is also important in making steel and is commonly used as an acid neutralizer in soils (Tums, the stomach antacid, has essentially the same composition as limestone).

**The La Salle Limestone**

The La Salle Limestone (fig. 11) is geographically restricted to the region along the crest of the La Salle Anticlinorium (figs. 16 and 17) in La Salle and Woodford Counties. The limestone occurs in

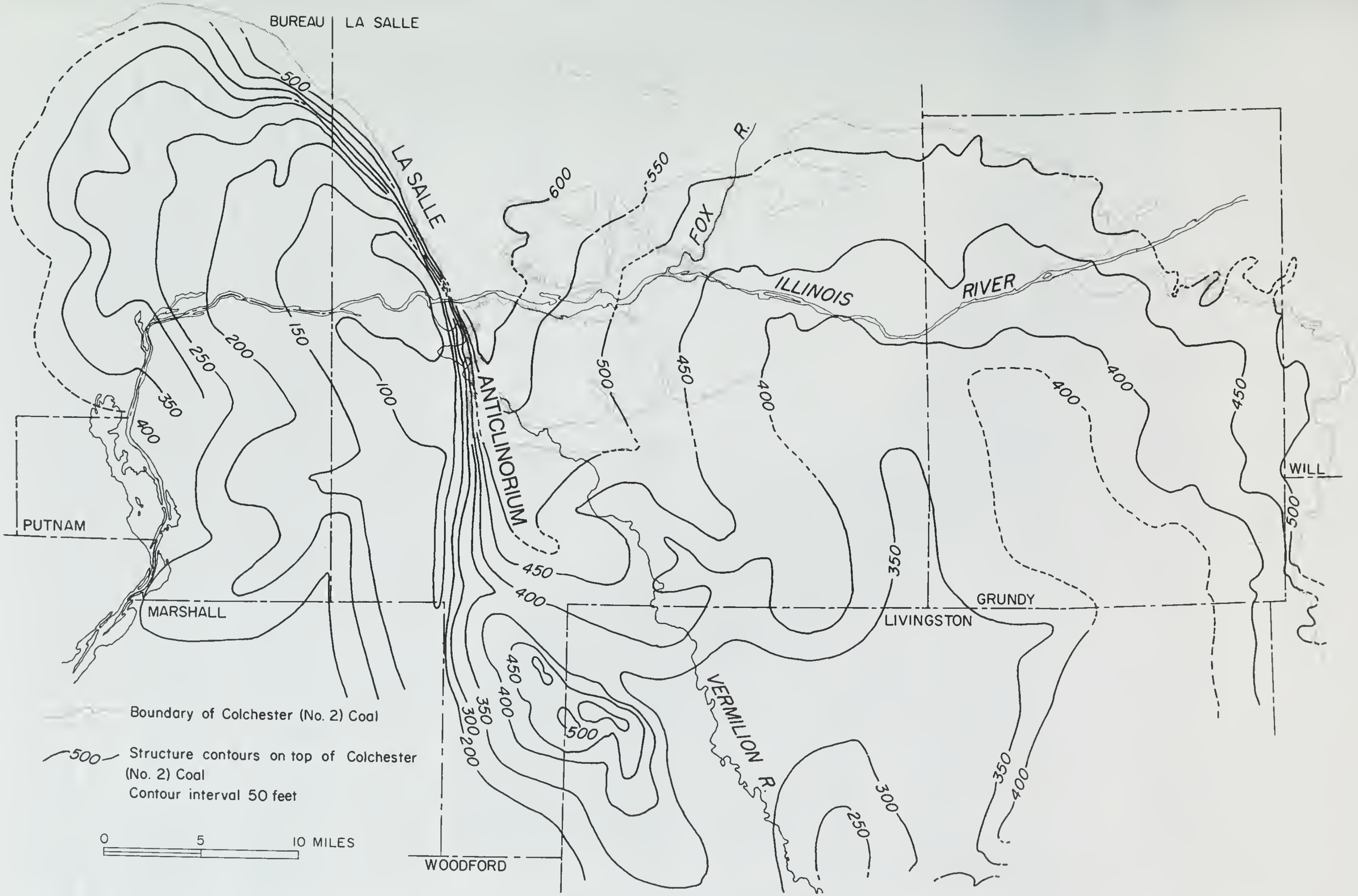
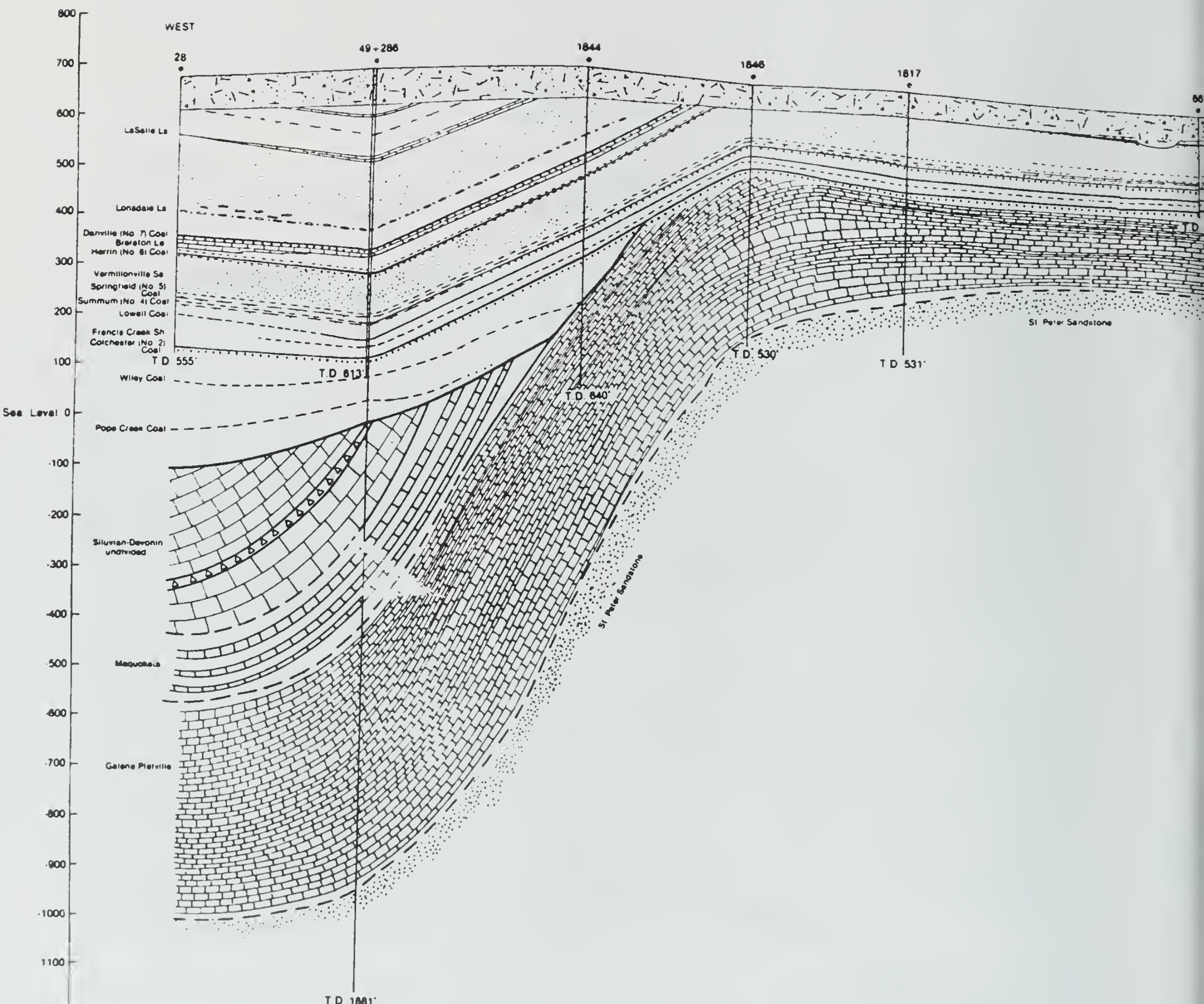



**Figure 16** Structure contour map of the Colchester Coal showing the La Salle Anticlinorium, (modified from Jacobson 1985).




several forms depending on the types and abundance of organisms, amount of clay-sized particles washed into the area during deposition, the amount of postdepositional drying of the sediment from exposure to air, and postdepositional folding. Fossils may occur at any position within the limestone, but the most fossiliferous zones are the farthest from the axis of folding and below green clay partings. The largest and least broken fossils occur in the uppermost beds of the unit. The La Salle Limestone, near the La Salle Anticlinorium, is characterized by brecciation. Several beds, originally consisting of gray, lime mudstone, have been broken into angular pieces and recemented by white calcite. Few fossils are present in this form of the limestone. In the Illinois Cement Company quarry, a second form of brecciation is present in which angular limestone fragments are surrounded by clay. This form of brecciation (reibungsbreccia) was produced by differential movement of brittle limestone layers and flexible shale layers along bedding planes during the folding (fig. 18).

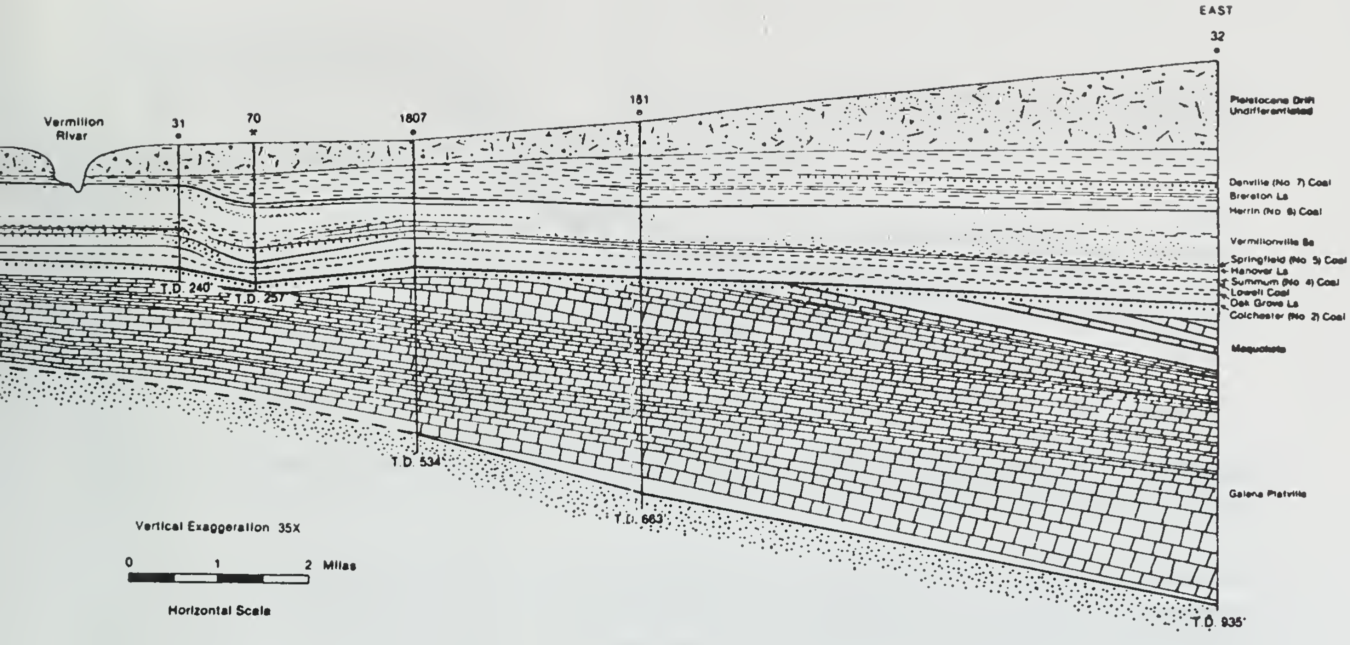



**Figure 17** East–west cross section of the La Salle Anticlinorium near Lenore, Illinois.

The most fossiliferous and least deformed limestone occurs at the west end of the quarry where the limestone is flat-lying (fig. 19). To the east the limestone thickens slightly. It rises some 90 feet over a horizontal distance of about 800 hundred feet as it rides up the flank of the anticline and thins from about 30 feet to 10 feet (figs. 20 and 21).

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## STOP 3 Starved Rock Clay Products Clay Pit (SW, Sec. 21, T33N, R2E, La Salle County, La Salle 7.5-minute Quadrangle)

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### Site History

This site has been the location of a clay pit since the turn of the century. The clay under the Colchester Coal is mined here for fire clay (fig. 22). In 1910 Gilbert Cady of the Illinois State Geological Survey interviewed Mr. F. M. Drummond, the manager of the clay pit. Mr. Drummond indicated that it cost $0.17 per ton to strip the overburden to a depth of 25 feet. The fire clay brought $1.50 per ton in carload lots. In 1930, 50,000 tons of fire clay was shipped by truck from this site to Rock Island. The material above the fire clay was "double stripped." The overburden above the Colchester Coal was removed, and the coal was then mined and sold locally. With the coal removed, the fire clay below it was then mined.

The same procedure is used today. The cost of overburden removal is estimated to be as much as $4.50 per ton. The coal is sold locally for $12.00 per ton, and the fire clay is sold for $5.00 per ton. The fire clay is sold to the Dixon-Marquette Cement Company in Dixon, the Marseilles Brick Company in Marseilles, and the Streator Brick Company in Streator.

### Site Geology

The unconformity between the Ordovician and Pennsylvanian strata is interesting at this site. At the north end of the pit, the Pennsylvanian-age clay rests directly on the St. Peter Sandstone; but at the

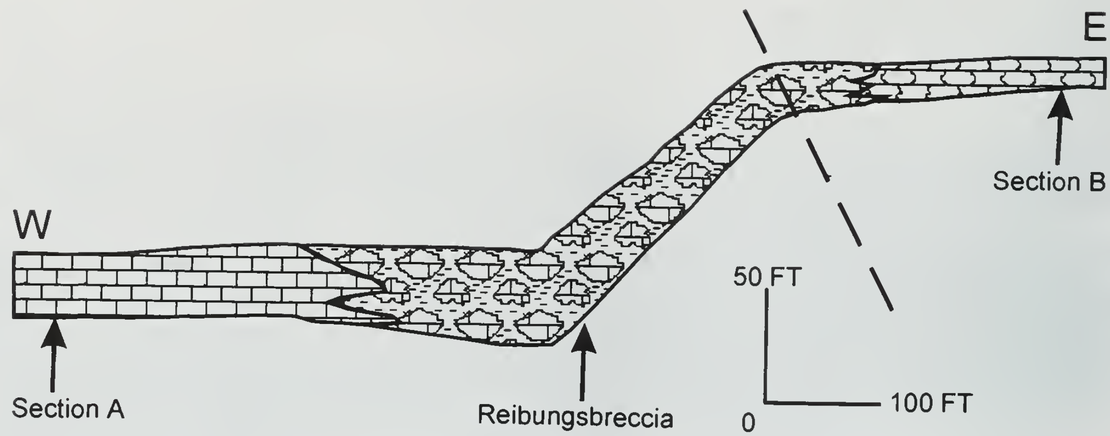


**Figure 18** Generalized cross section of the La Salle Limestone in the area of the Illinois Cement Company quarry showing the location of reibungsbreccia along the fold axis.

south end, the clay rests directly on the overlying Platteville Dolomite (fig. 22). The clay, which appears to be a floodplain or lower delta plain deposit, contains numerous lenses of reworked St. Peter Sandstone that mark the locations of small stream channels. The St. Peter Sandstone was eroded from the strata exposed in the crestal area of the anticlinorium, transported by streams, and deposited in the channels. Note the very uniform grain size of these reworked deposits. Note, too, that the sand lenses are much more strongly cemented than the original St. Peter Sandstone. The sandstone lenses are called "flint rock" by the pit workers.

The clay pit gives an impression of a moonscape or a bombed-out war zone (fig. 23) because of the nature of the materials and the mining procedure. A power hoe is used to excavate the clay from between the lenses and masses of hard sandstone. This chaotic mined surface is then buried during the reclamation process.

This is a good place to collect samples. The surface of many of the sandstone or dolomite masses is coated with crystals of pyrite. Petrified wood occurs at the top of the coal. Some petrified stumps have been observed here as well.

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**STOP 4 Matthiessen State Park, Dells Area** (SW, Sec. 29; NE, NE, NE, Sec. 31; and NW, NW, NW, Sec. 32, T33N, R2E, La Salle County, La Salle 7.5-minute Quadrangle)

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Matthiessen State Park was named for the late Frederick William Matthiessen, a prominent industrialist and philanthropist from La Salle. The land was originally purchased by him near the end of the 19th century and used as a private park for a number of years. Matthiessen employed nearly 50 people to construct trails, bridges, and stairways and to check dams. At that time, the park was called Deer Park, referring to the large deer population in the area.

The original 176-acre park consisted of a long narrow canyon with a small stream flowing through it. The sandstone formations in the canyon (St. Peter Sandstone) were originally called the Dells, and this name has stayed through the history of the park. After Matthiessen passed away, the park was given to the Department of Conservation (now Department of Natural Resources). It was opened as a public park in 1943 and renamed in honor of Mr. Matthiessen. Since then, acquisitions of more areas along the main Dell, some former prairie land, and some forest land to the south have increased the park's size to a total of 1,938 acres.

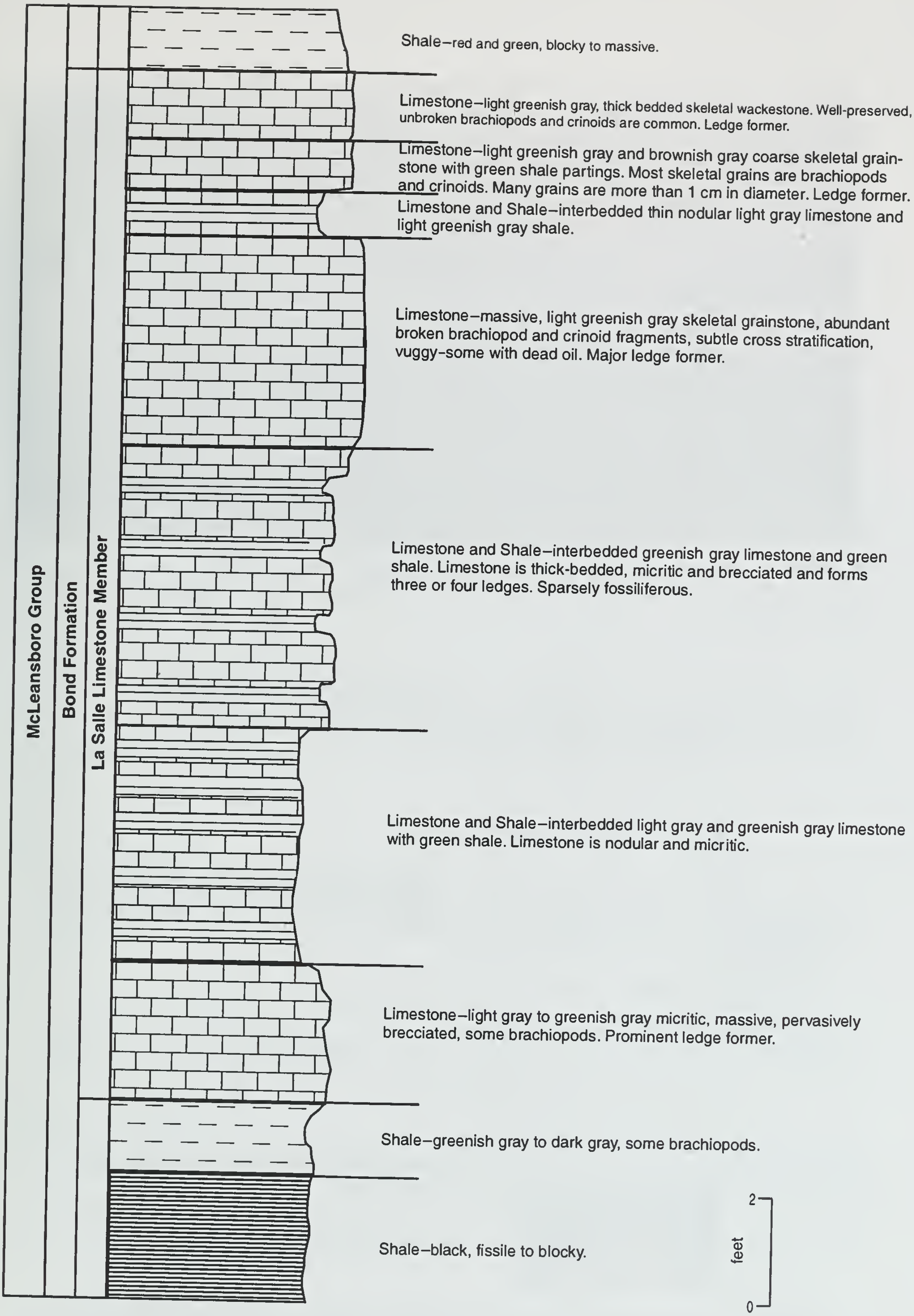


**Figure 19** Section measured by Nelson and Malone at the Illinois Cement Company Quarry (July 1996) along the north bank of the Little Vermilion River just east of the bridge (section A in figure 18).

**Figure 20** La Salle Limestone at the Illinois Cement Company Quarry (Stop 2) on the west flank of the La Salle Anticlinorium. Note how the limestone rises and thins to the right on the flank of the structure, (photo by R.J. Jacobson).

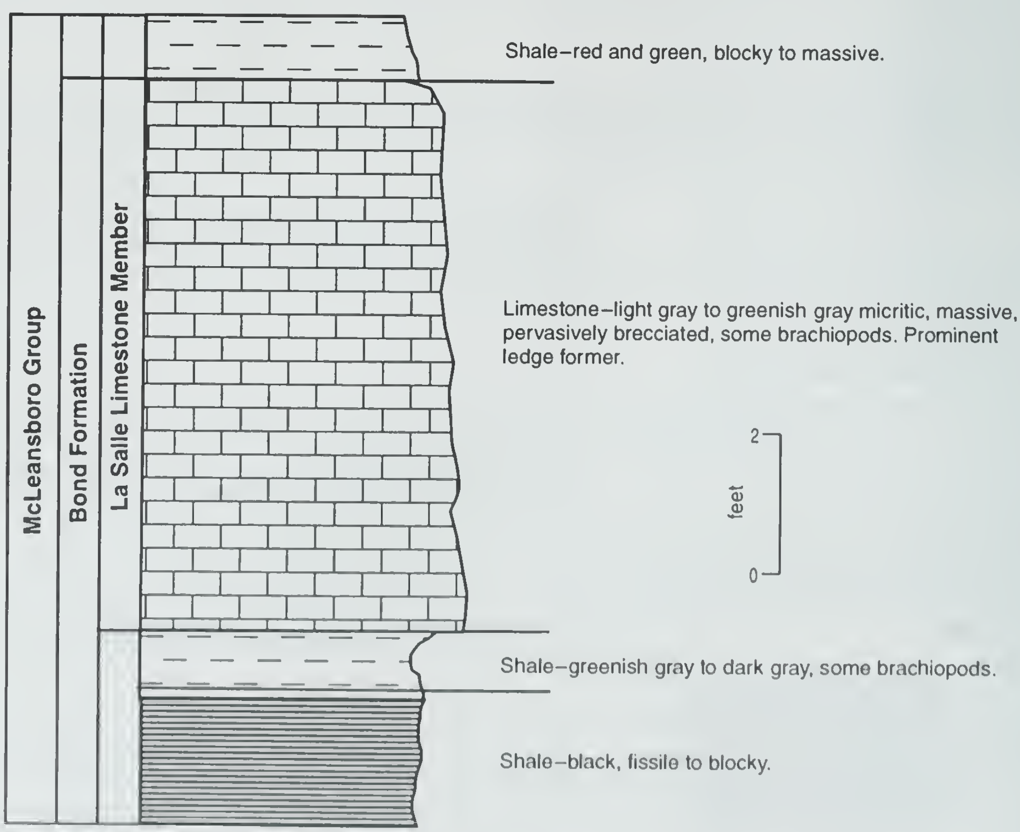


**Figure 21** Section measured by Nelson and Malone at the Illinois Cement Company Quarry (July 1996) at the east end of the quarry about 400 feet east of the crest of the La Salle Anticlinorium (section B in figure 18).

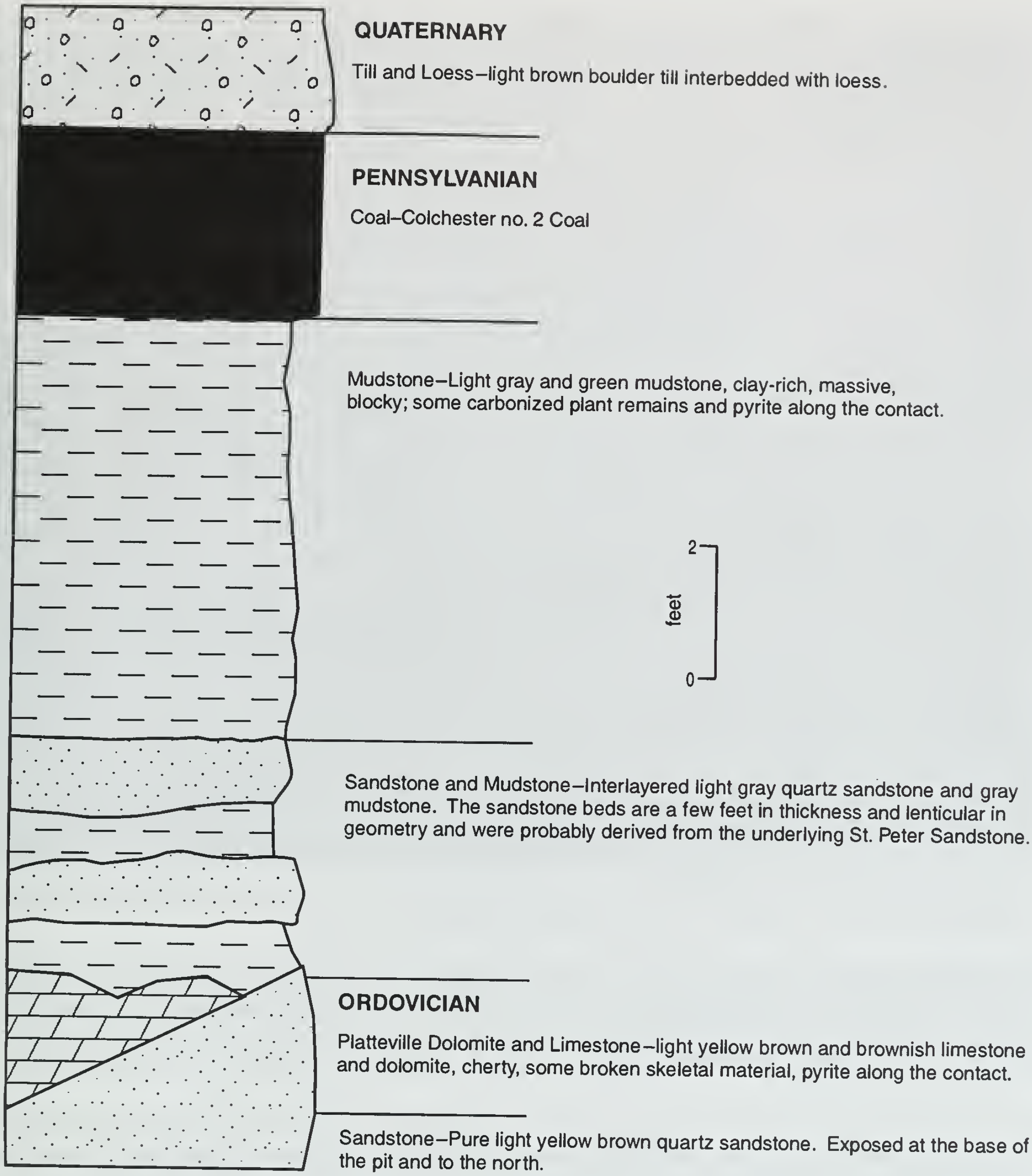


**Figure 22** Section measured by Nelson and Malone at the Illinois Cement Company Quarry (July 1996) at the Starved Rock Clay Products pit just south of Starved Rock State Park.

## Geology of the Park

The many unique and beautiful rock formations exposed in the Upper and Lower Dell areas of the canyon are composed primarily of St. Peter Sandstone (fig. 12). The Upper Dell begins at Deer Park Lake and continues to Cascade Falls, where the canyon descends 45 feet to the Lower Dell. In total, the canyon is about 1 mile long from Deer Park Lake to the Vermilion River. Closer to the Vermilion River, where the Platteville Limestone overlying the St. Peter Sandstone is visible, the rocks are folded, and the strata dip steeply toward the river along the west flank of the La Salle Anticlinorium.

At the park and nearby areas, the Platteville Dolomite (Ordovician) rests directly on the St. Peter Sandstone (Ordovician) (fig. 2). Elsewhere, in northern Illinois, a unit called the Glenwood Formation, consisting of interlayered sandstone and shale, occurs between the Platteville and the St. Peter. In

**Figure 23** Exposure of the unconformity surface at the base of the claystone beneath the Colchester Coal. This location has many eroded and irregular blocks of Platteville Limestone.

areas strongly affected by uplift along the La Salle Anticlinorium, however, the Glenwood Formation was eroded away before the Platteville Dolomite was deposited. The interval marked by the erosion surface on the top of the St. Peter Sandstone represents one of several unconformities present in the Paleozoic succession that we have seen on this field trip.

Pennsylvanian strata are also well exposed along the Vermilion River in the park. That these rock layers dip (tilt) less steeply than the Platteville and St. Peter Formations indicates that the older Ordovician rocks were tilted both during one of the episodes of uplift along the La Salle Anticlinorium before the Pennsylvanian strata were deposited and again when the Pennsylvanian strata were folded. In this area, the unconformity between the Pennsylvanian and Ordovician rocks, marked by the significant difference in their dips, is known as an angular unconformity (figs. 4B and 17).

**Platteville Dolomite** The Platteville Dolomite is classified as a group by geologists and consists of five formations, many of which are recognized by only slight differences in subsurface samples. Because the units of the group are difficult to distinguish in surface exposures, we will discuss the Platteville as one rock unit. The Platteville Dolomite underlies all of the region except for a small area in the north-central part. It also occurs in small outliers west and southwest of Ottawa that represent remnants left behind when the surrounding rocks were eroded away.

The Platteville Dolomite consists of brown, buff, and gray, finely crystalline, compact dolomite and fossiliferous brown and gray, finely granular (or lithographic) dolomitic limestone that has a distinctive mottled appearance. At several horizons, lenses and nodules of chert are common. The Platteville

**Figure 24** Side breccia in the Ordovician Platteville Formation gives evidence of tectonic activity along the La Salle Anticlinorium during depostion of the Platteville, (photo by R.J. Jacobson).

is 125 to 140 feet thick in the vicinity of Marseilles, but in the immediate area, east of the La Salle Anticlinorium, thicknesses of more than 100 feet are attained only locally.

Along one of the trails we will take, we can see evidence that the La Salle Anticlinorium was already active during the Ordovician when the Platteville was being deposited. Along one major horizon, we can see (fig. 24) an intensely brecciated zone in the Platteville. Willman and Kolata (1978, p. 16) called this breccia a slide breccia and speculated that it was caused by topographic relief that was developed along the La Salle Anticlinorium.

**Development of the Dells**

The Dells area, developed in St. Peter Sandstone, is characterized by box canyons. The ends of the box canyons mark the present positions of waterfalls and rapids that have retreated by headward erosion up a small, unnamed tributary of the Vermilion River (fig. 25). The development of these prominent waterfalls is related to the much larger-scale events that created Buffalo Rock. As the Ilinois River was deepening and cutting cascades through the St. Peter Sandstone, the Vermilion River was deepening and cutting through the overlying Pennsylvanian strata and the Platteville Group. The rate of deepening and headward erosion along this unnamed tributary was primarily controlled by the level of the Vermilion River until the tributary had cut down to the St. Peter Sandstone. Falls developed because the sandstone was more resistant to headward erosion than the Platteville Group or the overlying Pennsylvanian rocks.

As rain water percolates downward through the surficial glacial sediments, Pennsylvanian strata, the Platteville Group, and finally into the St. Peter Sandstone, it dissolves a variety of chemicals from the sediments and rocks. By the time the groundwater reaches the St. Peter Sandstone, it is highly charged with iron as well as other chemicals. Bright yellow, brown, or orange strains along the canyon walls

**Figure 25** Falls and caves in the lower Dells at Matthiessen State Park in Ordovician St. Peter Sandstone, (photo by W.T. Frankie).

mark the locations of seeps and springs, many of them controlled by joints, where the groundwater evaporates and the dissolved iron precipitates. Some dissolved minerals precipitate at these seeps as the soft, light colored powders called efflorescence. Strawberry Rock (fig. 26-A) and Devils Paint Box (fig. 26-B) are two places to see these effects of chemicals in water.

**Erosion of the St. Peter Sandstone**

The Dells are an excellent place to examine the various effects of erosion on the St. Peter Sandstone. Potholes are formed where strong stream currents swirl cobbles and pebbles in eddies. As the swirling cobbles and pebbles grind holes in the sandstone, they are ground down themselves. The strong current flushes the sand from the hole. As long as fresh cobbles and pebbles are available and the current can flush fines, the potholes enlarge. The Giant Bath Tub (fig. 26-C) is a good place to see a pothole.

As the Illinois River rapidly cut down to successively lower levels, it caused erosional nick points to form that advanced upstream (headward) in the Vermilion River and the tributaries of both streams. Where the erosional nick point encountered the resistant layer of the St. Peter Sandstone, the nick point enlarged to form water falls. Cascade Falls (fig. 26-D) marks the present position of this retreating erosional nick point. During high flow, the water at the base of the falls has excess energy and can attack the side walls. The attack is focused where the sandstone is the weakest because of reduced cementation or presence of major fractures. The caves on the west side of the stream below the falls (fig. 26-E) and the undercut cliff on the east side of the stream (fig. 26-F) demonstrate the erosive power of the stream. Note that large joints in the St. Peter Sandstone influence the orientation of the canyon walls just downstream from the falls.

Rapid deepening of the canyon as the nick point moved upstream formed the nearly vertical canyon walls of St. Peter Sandstone. In time, numerous, small, discontinuous vertical joints developed parallel

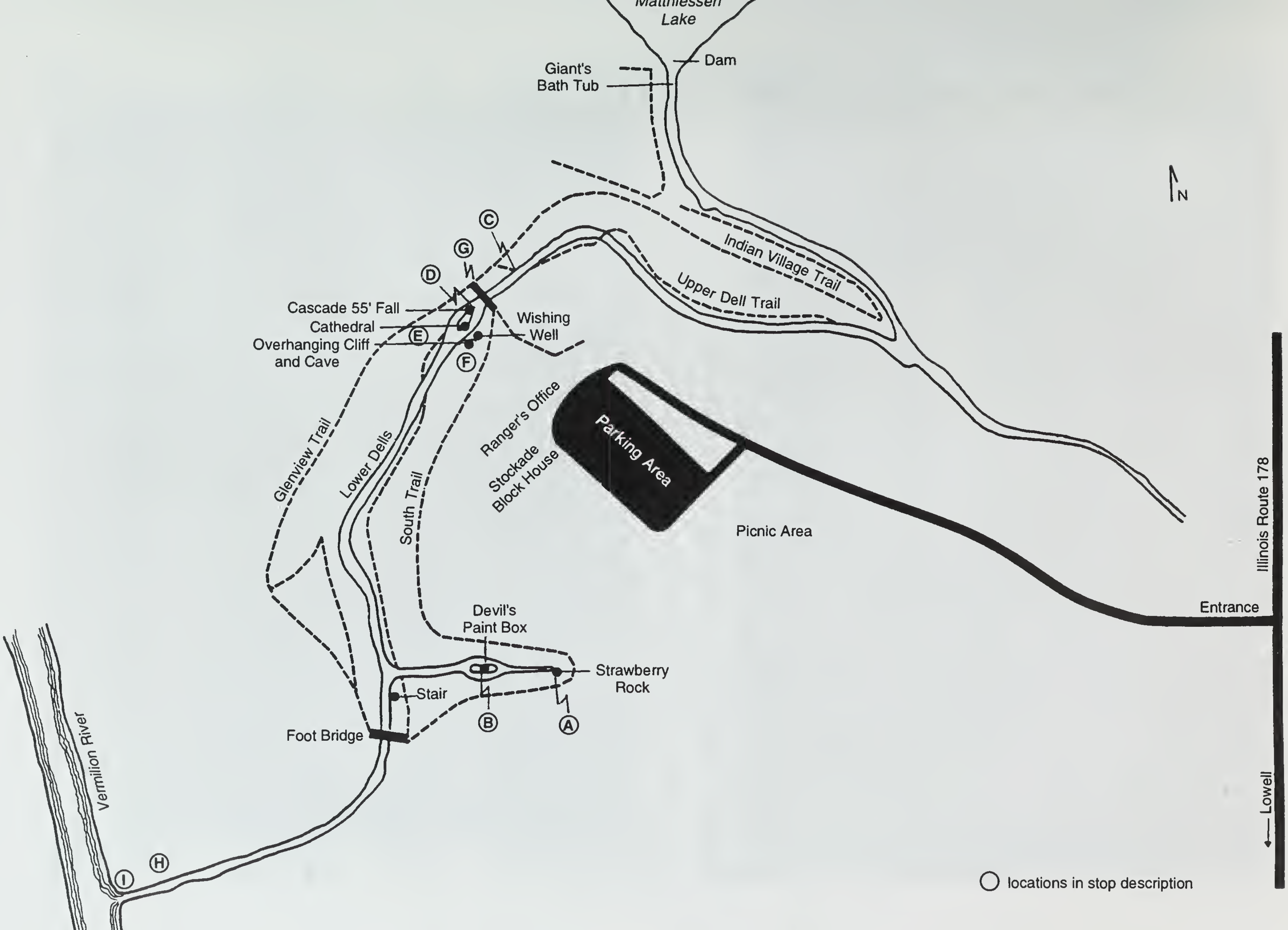


**Figure 26** Map of trails and stations in Mattheissen State Park where geology is discussed in the text and during the trip.

to the canyon wall. Where these joints intersect horizontal bedding planes and other joints produced by regional geologic conditions, they delineate and isolate blocks of sandstone from the main body of the unit. Slowly the cracks enlarge (by freeze-thaw and inwash of clay), and the detached blocks eventually fall or slide to the valley floor. Once there, weathering and stream action works to reduce them and carry them away. This mechanism gradually widens the valley and eliminates overhangs or vertical walls. A very young canyon has relatively straight vertical walls, whereas an older canyon has very irregular sloping walls and a winding plan view. Do you think this canyon is young or old?

**Relationships between the Ordovician Strata**

Although Pennsylvanian strata are present, the Ordovician strata are the most interesting rocks in the park. As you descend the stairs into the canyon, you descend through Quaternary-age glacial sediments and the lower portion of the Platteville Formation into the top of the St. Peter Sandstone, but the contacts between these units are obscured here by slope erosion, vegetation, and human activities.

From the west end of the upper foot bridge, you can take the trail to the north and examine potholes, or you can take the trail to the south to the lower bridge. A stairwell near the east end of the lower foot bridge provides access to the canyon floor.

The contact between the Platteville Group and the St. Peter Sandstone is evident at the west end of the upper foot bridge (fig. 26-G). Examine the outcrop and see if you can find the contact. The bedding in the basal Platteville looks thin and wavy compared with the relatively thick and regular beds in the uppermost part of the St. Peter. All of the strata dip to the west. Because you are looking in the general direction of the dip, the contact is difficult to see, but note that the same contact occurs about 30 feet higher under the stairs and seventy feet lower at the Vermilion River (fig. 26-I).

The lower Platteville strata are well exposed at the mouth of the stream entering the Vermilion River (fig. 26-I). This is the best location to observe the character of the Platteville Dolomite in the park. The Vermilion River here flows along the strike direction of the beds; where the mouth of the creek enters the Vermilion River it cuts across the strike of the beds to reveal that they are dipping 27° to 34° to the west (fig. 27). Just 200 feet to the east, the rocks dip only a few degrees to the west. This steepening of the dip defines the flank of a fold. Just to the east of these steeply dipping rocks (figs. 24 and 26-H), the bedding within the Platteville is disturbed, and the Platteville is broken into irregular clasts. This is one of the breccias that Willman and Kolata (1978) interpreted as a rock slide or slump that occurred as the La Salle Anticlinorium was beginning to develop during the Ordovician.

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**STOP 5 Moline Consumers Company, Vermilion Quarry** (SW, NW, and NE, SW, Sec. 8, T32N, R2E, La Salle County, La Salle 7.5-minute Quadrangle)

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**Site History**

Moline Consumers Company began quarrying the Plattville Limestone here in the mid-1980s. Prior to that time, this was a clay pit where the same fire clay as at stop 3 was mined. The limestone quarry (fig. 28) was opened with initial quarrying at the south end of the property in a strip along the river. Since then, the pit has been expanded to the north. There are sufficient limestone reserves for several more decades of quarrying.

**Site Geology**

Note that the beds here dip gently to the west. Careful examination of the wall along the ramp into the quarry reveals some interesting displacements and rotation of the bedding planes. These features appear to be related to both the continued folding of the La Salle Anticlinorium and the collapse of a small cave. A few, near-vertical, clay filled fractures that predate the deposition of the Pennsylvanian fire clay are present along the ramp and quarry walls. The structural features here suggest that uplift

**Figure 27** Steeply dipping Platteville Formation along the west flank of theLa Salle Anticlinorium near the mouth of the creek at Vermilion River, Matthiessen State Park, (photo by W.T. Frankie).

**Figure 28** Platteville Dolomite (Ordovician age) at the Moline Consumers Company, Vermilion Quarry, at stop 5 (photo by W.T. Frankie).

of the anticlinorium was accompanied by small-scale displacements along near-vertical faults. These features indicate that here the folding was likely caused by bending (draping of the rocks over a vertically uplifted block) rather than by buckling of the rocks due to horizontal compression (like the rumples that form if you try to push a carpet across the floor).

In this quarry, the Platteville is generally a limestone rather than the dolomite (dolostone) that is more typical of the Platteville in northern Illinois. Bedding is wavy, and the limestone shows distinctive light and medium gray splotches that suggest bioturbation. These beds are generally fossiliferous, and a variety of well preserved fossils have been collected here. *Receptaculities* (see illustrations of fossils in this guidebook) is a very distinctive fossil and an index fossil of the Ordovician.

The fire clay below the Colchester Coal is exposed in the old clay pit area north of the quarry proper. Pyrite crystals occur in the clay and encrust limestone at the base of the clay. This is an excellent location to collect pyrite crystals.

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**STOP 6 North Bank of the Vermilion River** (SE, SW, NE, SE, Sec. 8, T32N, R2E, La Salle County, La Salle 7.5-minute Quadrangle)

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Park along the road, but do not block the river access area at the end of the road. This access is used by canoers. Wildcat Rapids, the best canoeing reach of the Vermilion River, begins just upstream.

**Wildcat Rapids**

Wildcat Rapids occurs where the Vermilion River is attempting to cut downward through gently dipping strata of the Platteville Dolomite. The Platteville is acting as a local erosional base level. The river rapidly cut a narrow, steep-sided valley down through Pennsylvanian strata until it encountered the more resistant Platteville. The erosional energy is now focused on lateral cutting until these more resistant strata are breached.

**Geologic Features**

**Bentonite Beds** Careful examination of the strata along the north bank reveals a prominent bedding separation, a break in the succession of dolomite layers. This separation may mark the position of a thin bentonite bed. Bentonite is a collective term for the clay formed by weathered and altered volcanic ash. This bed apparently marks an ash fall event, one of several documented bentonite beds in the Platteville Group (Kolata, Frost, and Huff, 1986).

**Structures within the Platteville** If you carefully trace this bedding separation, you will note that it is offset slightly (a few inches) along what appear to be vertical joints. If there has been differential motion, the fracture should be reclassified as a fault. The faults all have a strike ranging from north 70° west to north 75° west. This is the same trend as in the Moline Consumers quarry.

**Ordovician-Pennsylvanian Unconformity** The outcrop on which you are walking was very close to the ground surface during the Pennsylvanian just prior to deposition of the rocks that lie below the Colchester Coal. At that time, a well developed channel was cut into the Platteville Dolomite (fig. 29). PLEASE DO NOT HAMMER ON THE CHANNEL DEPOSITS. Mudstones and fine sandstones were deposited in this channel. The steep sides of the channel and the slope of the bottom indicate that there was measurable local topographic relief prior to deposition of the sub-Colchester strata. The muscovite mica that is abundant in the fine grained sandstone indicates that the uplifted and eroding igneous and metamorphic rocks at the core of a mountain range were present somewhere upstream. All the sandstone in this part of the Pennsylvanian section in Illinois contains muscovite mica, and the explanation is that the mica was brought into Illinois by one or more large river systems that drained the igneous and metamorphic rocks in Ontario, Quebec, and New England that were uplifted during part of the Appalachian Orogenic Event.

**Figure 29** Small channel filled with Pennsylvanian clastic sediments (sandstone, shale, siltstone, claystone) cut into the Pennsylvanian-Ordovician unconformity surface on the upper surface of the Platteville Formation at stop 7 (photo by R.J. Jacobson).

The channel here trends north 72° west, the same as several of the small vertical faults. This trend indicates that the channel is structurally controlled. Other evidence for that interpretation is provided by the dip of the bedding within the channel. The strata along the west side of the channel dip very steeply to the east, whereas those along the east side display a normal horizontal dip.

In May 1996, an excellent longitudinal section of a straight cephalopod (a distant ancestor to the octopus and squid) was uncovered on a bedding plane of the limestone just west of the channel. PLEASE LET HIM BE SO THAT OTHERS MAY VIEW HIM.

If you look to the west (downstream), you will see a large cut bank on the other side of the river. That is stop 7. At times when the river is very low or during the winter, it is possible to walk down the river to get to the cut bank rather than making a long hike in from the road (as indicated in the road log).

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**STOP 7 Cyclothems in the Carbondale Formation** (Pennsylvanian: Desmoinesian Series) of La Salle County, Illinois (Sec. 8, T. 32N., R. 2E., T32N, R2E, La Salle County, La Salle 7.5-minute Quadrangle)

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The site is located in the Margery C. Carlson Nature Preserve owned by the Illinois Department of Natural Resources. Groups of more than 25 people must check with the site superintendent at Starved Rock State Park before entering the preserve.

Park on the shoulder of East 675th Road and walk down the gravel road (not passable by vehicles) to a concrete block building. Go around the left (west) side of the building and walk to your right (east). Follow the path along the top of the bluff to the site. As you will find, three bedrock outcrops along the cutbank of the Vermilion River are periodically eroded and exposed by the river.

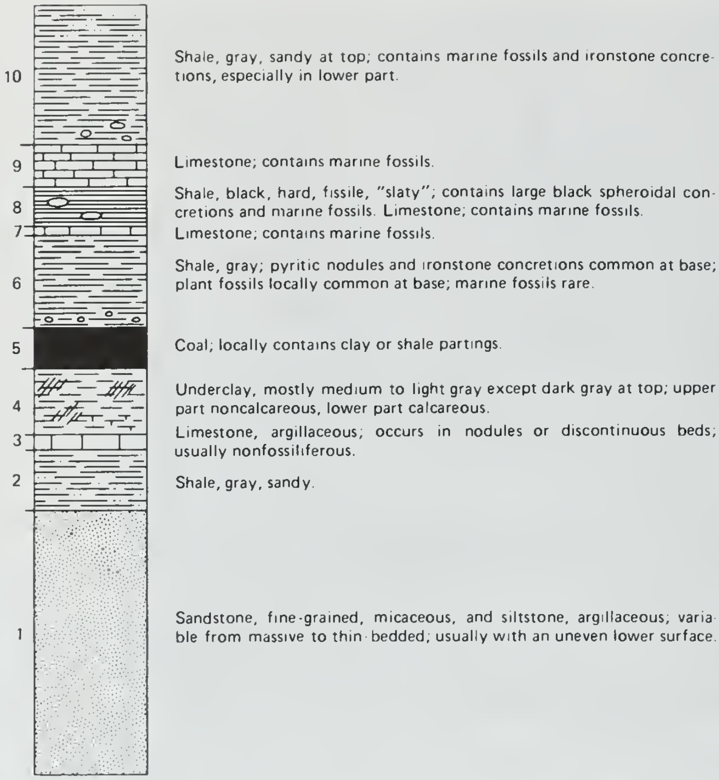


**Figure 30** Ideal Pennsylvanian cylcothem (after Willman and Payne 1942).

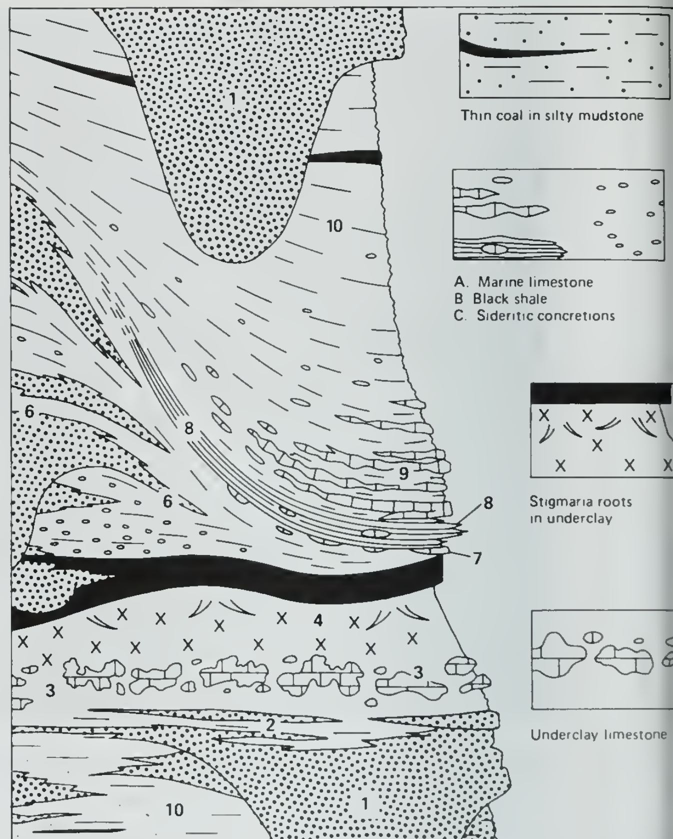


**Figure 31** Facies relationships in a typical cyclothem (from Ba and Shabica 1980).

## Significance

The site is one of the best exposures for the observation of cyclothems in the northern Illinois Basin. Four complete cyclothems and part of a fifth are present. As elsewhere in the region, the Pennsylvanian strata unconformably overlie Ordovician rocks. Dolomites of the Ordovician Galena and Platteville Groups can be seen in the riverbed, and the unconformity itself may be exposed locally.

Cyclothems have received widespread attention by geologists studying Pennsylvanian strata. A cyclothem is a succession of strata representing a single cycle of deposition. An ideal Pennsylvanian cyclothem (fig. 30) consists of 10 units, from a basal sandstone in unconformable contact with an underlying cyclothem, through coal, black shale, and limestone to the uppermost unit, a shale becoming sandy at the top. Figure 31 better illustrates the nature and interrelationships of the various facies present in a cyclothem.

Udden (1912) recognized cyclic repetition of strata near Peoria southwest of this locality; he grouped these units into cycles of deposition beginning with a coal at the base of each cycle. Savage (1927) observed the wide distribution of unconformities at the base of some sandstones and proposed separating the Carbondale Formation from underlying rocks along such an unconformity. Weller (1930) adopted the base of the sandstone as the horizon separating adjacent sedimentary cycles. They have been referred to variously as cycles (Udden 1912, Weller 1930), suites (Wanless 1929), and cyclical formations (Wanless 1931, Weller 1931). Finally, Wanless and Weller (1932) proposed the term cyclothem "to designate a series of beds deposited during a single sedimentary cycle of the type that prevailed during the Pennsylvanian Period."

The original intent was to use cyclothems for regional stratigraphic correlation (Weller 1930 and 1931, Wanless and Weller 1932). Wanless and Weller intended the term to have the same rank as a formation, the smallest unit that can be recognized and mapped. However, the discontinuous nature of many of the rock types and the limited extent of the erosional surfaces proved to limit the usefulness of cyclothems for widespread correlation. Modern studies of cyclothems (Weibel 1996) have focused on depositional environments of Pennsylvanian strata and the relationships of the cyclothem origins to Pennsylvanian paleoenvironments and paleogeography (that is, the past enivronments and geography). These more recent studies have found that the black shales, which represent the maximum water depth of the marine transgressive part of the cycle, are fairly widespread and useful in the correlation of Pennsylvanian rocks across wide areas of the midcontinent.

Weller (1964) has summarized several hypotheses to explain cyclic sedimentation. Many investigators believe that cyclothems were formed by repeated advance and abandonment of deltaic lobes, combined with marine transgressions that resulted from compaction and subsidence of the abandoned delta lobes. The often cited model is the Mississippi Delta complex and the numerous delta lobes that have existed throughout Holocene time. Shabica (1979) discusses deltaic models generated under varying sea level conditions for northem Illinois. Other researchers relate the cycles to pulses in the rate of sea floor spreading and resulting continental drift and collisions which literally may have caused the transgression of deeper oceanic waters upon the continents. And others believe that the periods of glaciation which occured in parts of the globe during the Pennsylvanian may have contributed to the rise and fall of sea level as the waters are tied up in glacial ice and then remelted during interglacial times. It may be that several of these factors were active during the Pennsylvanian.

The Lowell site is situated on the west flank of the La Salle Anticlinorium (essentially a monocline here), which was actively rising during the Pennsylvanian. Consequently, the 115 ft (35 m) of strata at this locality represents an interval during which more than 200 ft (60 m) of strata was deposited to the south in the deep basin. Strata from the Pennsylvanian-Ordovician unconformity to the Vermilionville Sandstone Member are exposed (figs. 11 and 32). The section comprises five cyclothems: Tonica, Lowell, Summum, St. David, and part of the Brereton. (Hopkins and Simon [1975] provide a list of cyclothems in Illinois.)

**Description of Strata Exposed at the Stop**

Figure 32 represents the units that are exposed at this site. A description of the units (leading numbers refers to the numbers in figure 32 for each unit; numbers in parenthesis refer to lithologic units in the ideal cyclothem shown in figure 30) from top to bottom. The section exposed is described as follows:

**BRERETON CYCLOTHEM**

1. Sandstone - brownish gray, thin bedded; interbedded with sandy shale; contains many black carbonaceous partings (unit 2)
2. Sandstone - brown, fine grained, poorly sorted, occuring in one massive bed (unit 1)

**ST. DAVID CYCLOTHEM**

3. Shale - gray lower part fossiliferous (gastropods); contains layers of discoid, septarian, fossiliferous ironstone concretions; grades into underlying shale (unit 10)
4. Shale - black, well bedded, hard, “slaty”; contains thin phosphatic lenses and laminae, especially in lower part; occasional gray limestone nodules up to 1" (2.5 cm) thick; contains *Avicuopecten* in lower part (unit 8)
5. Shale - black, very calcitic and fossiliferous; *Marginifera* and crinoid debris; pyritic (unit 8)

**SUMMUM CYCLOTHEM**

6. Conglomerate - composed of poorly sorted, fine grained limestone particles (<0.5", <10 mm) in a pyritic matrix; fossiliferous

7. Claystone - medium dark gray, becoming lighter in color downward with some mottling; reddish in lower 10" (25 cm); contains irregular calcite masses up to 1" (2.5 cm) thick in bottom 21" (0.5 m); calcite throughout
8. Shale - light gray, fossiliferous, as below; contains several lenticular limestone units up to 3" (7.6 cm) thick (unit 10)
9. Limestone - light greenish gray, impure; nodular in lower part; fossiliferous with abundant productids and crinoid stems (unit 9)
10. Shale - medium gray, slightly green (unit 9)
11. Shale - medium dark gray, mottled with greenish gray; interbedded with medium gray, thinly laminated siltstone beds up to 3" (7.6 cm) thick (unit 8)
12. Shale - black, smooth, well laminated, relatively soft, coaly in parts (unit 8)
13. Claystone - medium olive gray; relatively firm and calcitic especially in lower 4' (1.2 m); a few small slickensided surfaces (unit 4)
15. Claystone - light greenish gray, yellowish cast; silty, noncalcareous; contains sandy limestone nodules up to 1" (2.54 cm) thick in the lower 8' (20 cm) (unit 4)
16. Limestone - light greenish gray, sandy, clayey, massive (unit 3)
17. Sandstone - light greenish gray, fine grained, calcitic, clayey, thin-bedded (unit 1)

**LOWELL CYCLOTHEM**

18. Shale - light greenish gray, fine micaceous, sandy near top; contains small nodules of sandy gray limestone which weather rusty; contains an 8" (20 cm) mottled, soft, red and green shale 1' (0.3 m) from base; interval mostly covered (unit 10)
19. Limestone - light gray, weathers reddish in part, septarian; fossiliferous: *Marginifera* (abundant), *Mesolobus*, *Ambocoelia*; forms a consistent nodular bed (unit 9)
20. Shale - medium gray, weathers tan, soft, slightly fossiliferous; contains several siderite nodules in lower part; contains a 7" (18 cm) zone of light olive gray, lithographic septarian limestone nodules 28" (0.7 m) from base; base 14" (35 cm) poorly bedded (unit 8?)
21. Shale - dark gray; fossiliferous; *Mesolobus*, *Marginifera*, *Neospirifer (unit 7?)*
22. Coal - contains several dull shaly bands (unit 5)

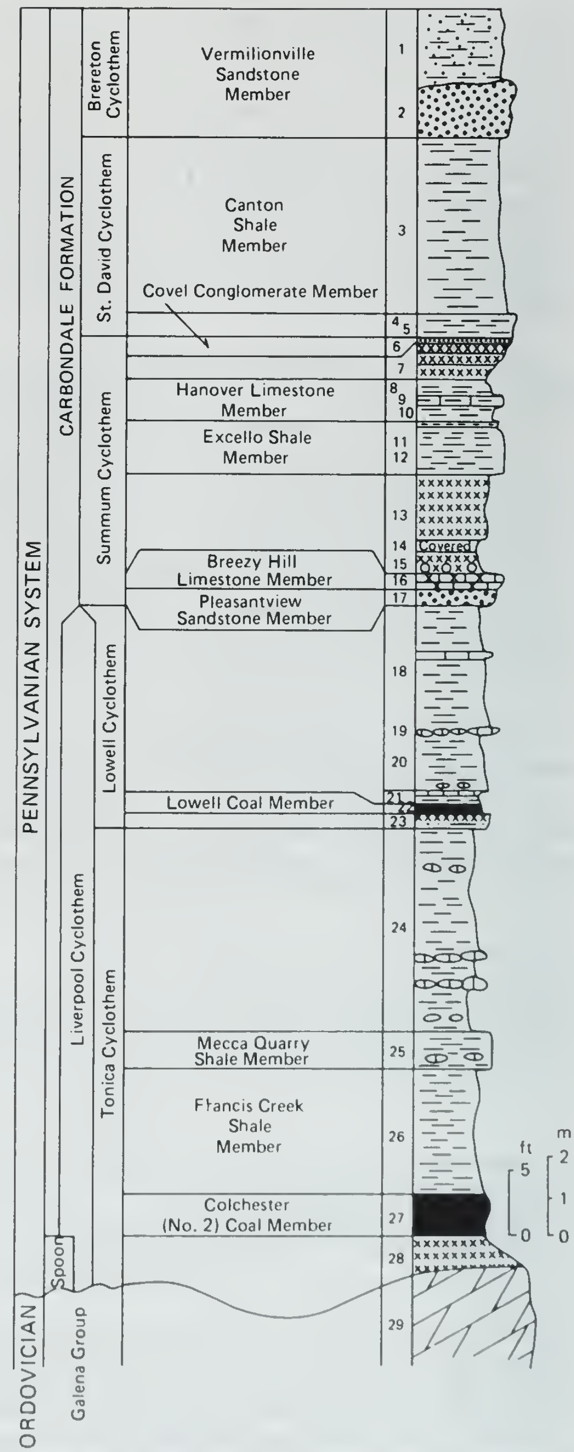


**Figure 32** Stratigraphic column of the Lowell site (after Smith et al. 1970).

**Figure 33** The excellent Quaternary section exposed over the La Salle Limestone (Pennsylvanian at the southwest corner of the Bailey Falls Quarry, Lone Star Industries. (Photo by W.T. Frankie)

23. Siltstones - medium dark gray, sandy, calcitic, micaceous; contains vertical plant impressions and charcoal streaks (units 1–4?)

**TONICA CYCLOTHEM**

24. Shale - dark gray, sandy, micaceous, generally thick bedded; contains two prominent zones of lenticular semilithographic septarian limestones up to 1.5' (0.5m) thick and containing a few fossils; several thinner and less persistent nodular limestone zones also present; a few crinoid stem fragments noted near base (units 9 and 10)
25. Shale - black, hard, "slaty"; contains large discoidal concretions of dark gray limestone up to 6" (15 cm) thick, mostly in lower 1' (0.3 m) (unit 8)
26. Shale - light gray, soft, thin bedded; contains a few sideritic concretions; generally not exposed (unit 6)
27. Coal - has been mined out locally (unit 5)
28. Claystone - gray, noncalcareous; where thicker than 8' (2 m), commonly consists of three beds; lower gray claystone, thin discontinuous green claystone or shale, and upper gray claystone (unit 4)

**BASE OF PENNSYLVANIAN - UNCONFORMITY**

**PLATTVILLE AND GALENA GROUPS, ORDOVICIAN**

29. Dolostone

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**STOP 8 Quaternary Strata Exposed in the Highwall of the Bailey Falls Quarry** (SW SW SE, Sec. 1, T32N, R1E, LA Salle County, La Salle 7.5-minute Quadrangle)

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We will walk down an abandoned quarry access road. Stream erosion has deeply incised into the road, making it impassable to vehicles. This location is unusual in that unlithified materials other than till are common here (fig. 33).

**Interpreted History**

The Illinoian-age sediments appear to have been preserved here in a tributary of the much larger Ticona bedrock valley (fig. 8). The Hulik and Sterling Hill Till members of the Glasford Formation represent two episodes of glacial advance across this area during the Illinoian Stage. There was some time

between these two glacial advances, and the Roby Silt was deposited in front of the advancing "Sterling Hill Glacier." The Roby Silt was later overridden by advancing glacial ice. After the Sterling Hill Till was deposited, there was sufficient time to develop an integrated stream drainage system that partially dissected the topographic surface to form a prominent soil profile. The Sangamon Soil is laterally persistent and is an excellent stratigraphic marker. The upper portion of the Sangamon Soil profile was removed by erosion and buried by the Peddicord. The Peddicord is, by definition, restricted to the buried Ticona valley and it tributaries; it represents a relatively short lived event. It is only 1 foot thick here, but more than 6 feet thick at the northeast corner of the quarry. The Peddicord Clay was overridden by the advancing Wisconsin Episode glacier that deposited the Tiskilwa Till. The "Tiskilwa Glacier" deposited materials at both the base of the ice (lodgement process) and at the terminus (meltout and flow processes). After the glacier deposited conspicuous end moraines, it retreated some distance to the east before re-advancing over the area. The Malden Till was deposited during this re-advance. At this location 6 feet of sand and gravel assigned to the Equality Formation occurs between the two tills. To the northwest 5.5 miles, 40 feet of mixed silts, sands, and clay occur between the two tills. After the retreat of the glacier, 1.5 feet of Peoria Silt (a wind-transported silt, or loess) was deposited. The modern soil profile has developed through this loess and into the till.

**Measured Section of Quarternary Materials at Stop 8**

| Pleistocene Series | Thickness in feet |
|---|---|
| Wisconsinan Stage | |
| Woodfordian Substage | |
| Peoria Silt: | |
| medium brown silty clay | 1.5 |
| Wedron Group | |
| Lemont Formation (Malden Till Member): | |
| medium brown, sandy silty clay with sparse embedded pebbles and cobbles | 4.0 |
| Equality Formation (unnamed tongue): | |
| sand and gravel, medium reddish brown, some clay matrix; top marked by a stone line | 6.0 |
| Tiskilwa Formation (undivided till): | |
| medium brown with strong red to pink cast, sandy silty clay with abundant embedded pebbles and cobbles | 6.0 |
| Equality Formation (Peddicord Tongue): | |
| clay, dark brown, silty | 1.0 |
| Illinoian Stage | |
| Jubileean Substage | |
| Glasford Formation (Sterling Till Member): | |
| gray-brown, hard, sandy silty clay with abundant embedded pebbles and cobbles. The B horizon of the Sangamon Soil profile gives the upper 3 feet a distinct yellow-orange color. | 12.0 |
| Roby Silt Member | |
| silty clay, tan and gray, laminated; some convuluted beds | 7.0 |
| Monican Substage | |
| Glasford Formation (Hulick Till Member): | |
| dark brown to gray, hard, sandy silty clay with embedded pebbles and cobbles | 12.0 |

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## GLOSSARY

The following definitions are taken from several sources in total or in part, but the main reference is: Bates, R.L., and J.A. Jackson, editors, 1987, Glossary of Geology: American Geological Institute, Alexandria, VA, 3rd Edition, 788 p.

**Ablation** Separation and removal of rock material and formation of deposits, especially by wind action or the washing away of loose and soluble materials.

**Age** An interval of geologic time; a division of an epoch.

**Aggrading stream** One that is actively building up its channel or floodplain by being supplied with more load than it can transport.

**Alluviated valley** One that has been at least partially filled with sand, silt, and mud by flowing water.

**Alluvium** A general term for clay, silt, sand, gravel, or similar unconsolidated detrital material deposited during comparatively recent time by a stream or other body of running water as a sorted or semi-sorted sediment in the bed of a stream or on its floodplain or delta, etc.

**Anticline** A convex upward rock fold in which strata have been bent into an arch; the strata on each side of the core of the arch are inclined in opposite directions away from the axis or crest; the core contains older rocks than does the perimeter of the structure.

**Aquifer** A geologic formation that is water-bearing and which transmits water from one point to another.

**Argillaceous** Largely composed of clay-sized particles or clay minerals.

**Arenite** A relatively clean quartz sandstone that is well sorted and contains less than 10% argillaceous material.

**Base level** Lowest limit of subaerial erosion by running water, controlled locally and temporarily by water level at stream mouths into lakes or more generally and semipermanently into the ocean (mean sea level).

**Basement complex** Largely crystalline igneous and/or metamorphic rocks of complex structure and distribution that underlie a sedimentary sequence.

**Basin** A topographic or structural low area that generally receives thicker deposits of sediments than adjacent areas; the low areas tend to sink more readily, partly because of the weight of the thicker sediments; this also denotes an area of deeper water than found in adjacent shelf areas.

**Bed** A naturally occurring layer of Earth material of relatively greater horizontal than vertical extent that is characterized by a change in physical properties from those overlying and underlying materials. It also is the ground upon which any body of water rests or has rested, or the land covered by the waters of a stream, lake, or ocean; the bottom of a watercourse or of a stream channel.

**Bedrock** The solid rock underlying the unconsolidated (non-indurated) surface materials, such as soil, sand, gravel, glacial till, etc.

**Bedrock valley** A drainageway eroded into the solid bedrock beneath the surface materials. It may be completely filled with unconsolidated (non-indurated) materials and hidden from view.

**Braided stream** A low gradient, low volume stream flowing through an intricate network of interlacing shallow channels that repeatedly merge and divide, and are separated from each other by branch islands or channel bars. Such a stream may be incapable of carrying all of its load.

**Calcarenite** Limestone composed of sand-sized grains consisting of more or less worn shell fragments or pieces of older limestone; a clastic limestone.

**Calcareous** Containing calcium carbonate ($CaCO_3$); limy.

**Calcined** The heating of limestone to its temperature of dissociation so that it loses its water of crystalization.

**Calcite** A common rock-forming mineral consisting of $CaCO_3$; it may be white, colorless, or pale shades of gray, yellow, and blue; it has perfect rhombohedral cleavage, appears vitreous, and has a hardness of 3 on the Mohs' scale; it effervesces (fizzes) readily in cold dilute hydrochloric acid. It is the principal constituent of limestone.

**Chert** Silicon dioxide ($SiO_2$); a compact, massive rock composed of minute particles of quartz and/or chalcedony; it is similar to flint but lighter in color.

**Clastic** Fragmental rock composed of detritus, including broken organic hard parts as well as rock substances of any sort.

**Closure** The difference in altitude between the crest of a dome or anticline and the lowest contour that completely surrounds it.

**Columnar section** A graphic representation in a vertical column of the sequence and stratigraphic relations of the rock units in a region.

**Conformable** Layers of strata deposited one upon another without interruption in accumulation of sediment; beds parallel.

**Delta** A low, nearly flat, alluvial land deposited at or near the mouth of a river where it enters a body of standing water; commonly a triangular or fan-shaped plain sometimes extending beyond the general trend of the coastline.

**Detritus** Material produced by mechanical disintegration.

**Disconformity** An unconformity marked by a distinct erosion-produced irregular, uneven surface of appreciable relief between parallel strata below and above the break; sometimes represents a considerable interval of nondeposition.

**Dolomite** A mineral, calcium-magnesium carbonate ($Ca,Mg[CO_3]2$); applied to those sedimentary rocks that are composed largely of the mineral dolomite; it also is precipitated directly from seawater. It is white, colorless, or tinged yellow, brown, pink, or gray; has perfect rhombohedral cleavage; appears pearly to vitreous; effervesces feebly in cold dilute hydrochloric acid.

**Drift** All rock material transported by a glacier and deposited either directly by the ice or reworked and deposited by meltwater streams and/or the wind.

**Driftless Area** A 10,000 square mile area in northeastern Iowa, southwestern Wisconsin, and northwestern Illinois where the absence of glacial drift suggests that the area may not have been glaciated.

**End moraine** A ridge-like or series of ridge-like accumulations of drift built along the margin of an actively flowing glacier at any given time; a moraine that has been deposited at the lower or outer end of a glacier.

**Epoch** An interval of geologic time; a division of a period.

**Era** A unit of geologic time that is next in magnitude beneath an eon; consists of two or more periods.

**Escarpment** A long, more or less continuous cliff or steep slope facing in one general direction, generally marking the outcrop of a resistant layer of rocks.

**Fault** A fracture surface or zone in Earth materials along which there has been vertical and/or horizontal displacement or movement of the strata on both sides relative to one another.

**Flaggy** Tending to split into layers of suitable thickness for use as flagstone.

**Floodplain** The surface or strip of relatively smooth land adjacent to a stream channel that has been produced by the stream's erosion and deposition actions; the area covered with water when the stream overflows its banks at times of high water; it is built of alluvium carried by the stream during floods and deposited in the sluggish water beyond the influence of the swiftest current.

**Fluvial** Of or pertaining to a river or rivers.

**Formation** The basic rock unit distinctive enough to be readily recognizable in the field and widespread and thick enough to be plotted on a map. It describes the strata, such as limestone, sandstone, shale, or combinations of these and other rock types; formations have formal names, such as Joliet Formation or St. Louis Limestone (Formation), usually derived from geographic localities.

**Fossil** Any remains or traces of an once living plant or animal specimens that are preserved in rocks (arbitrarily excludes Recent remains).

**Friable** Said of a rock or mineral that crumbles naturally or is easily broken, pulverized, or reduced to powder, such as a soft and poorly cemmented sandstone.

**Geology** The study of the planet Earth. It is concerned with the origin of the planet, the material and morphology of the Earth, and its history and the processes that acted (and act) upon it to affect its historic and present forms.

**Geophysics** Study of the Earth by quantitative physical methods.

**Glaciation** A collective term for the geologic processes of glacial activity, including erosion and deposition, and the resulting effects of such action on the Earth's surface.

**Glacier** A large, slow-moving mass of ice at least in part on land.

**Gradient(s)** A part of a surface feature of the Earth that slopes upward or downward; a slope, as of a stream channel or of a land surface.

**Igneous** Said of a rock or mineral that solidified from molten or partly molten material, i.e., from magma.

**Indurated** A compact rock or soil hardened by the action of pressure, cementation, and especially heat.

**Joint** A fracture or crack in rocks along which there has been no movement of the opposing sides.

**Karst** Area underlain by limestone having many sinkholes separated by steep ridges or irregular hills. Tunnels and caves resulting from solution by groundwater honeycomb the subsurface.

**Lacustrine** Produced by or belonging to a lake.

**Laurasia** A combination of Laurentia, a paleogeographic term for the Canadian Shield and its surroundings, and Eurasia. It is the protocontinent of the Northern Hemisphere, corresponding to Gondwana in the Southern Hemisphere, from which the present continents of the Northern Hemisphere have been derived by separation and continental displacement. The hypothetical supercontinent from which both were derived is Pangea. The protocontinent included most of North America, Greenland, and most of Eurasia, excluding India. The main zone of separation was in the North Atlantic, with a branch in Hudson Bay, and geologic features on opposite sides of these zones are very similar.

**Limestone** A sedimentary rock consisting primarily of calcium carbonate (the mineral, calcite).

**Lithify** To change to stone, or to petrify; esp. to consolidate from a loose sediment to a solid rock.

**Lithology** The description of rocks on the basis of color, structures, mineral composition, and grain size; the physical character of a rock.

**Local relief** The vertical difference in elevation between the highest and lowest points of a land surface within a specified horizontal distance or in a limited area.

**Loess** A homogeneous, unstratified deposit of silt deposited by the wind.

**Magma** Naturally occurring mobile rock material or fluid, generated within Earth and capable of intrusion and extrusion, from which igneous rocks are thought to have been derived through solidification and related processes.

**Meander** One of a series of somewhat regular, sharp, sinuous curves, bends, loops, or tums produced by a stream, particularly in its lower course where it swings from side to side across its valley bottom.

**Meander scars** Crescent-shaped, concave marks along a river floodplain that are abandoned meanders, frequently filled in with sediments and vegetation.

**Metamorphic rock** Any rock derived from pre-existing rocks by mineralogical, chemical, and structural changes, essentially in the solid state, in response to marked changes in temperature, pressure, shearing stress, and chemical environment at depth in Earth's crust (gneiss, schist, marble, quartzite, etc.).

**Mineral** A naturally formed chemical element or compound having a definite chemical composition and, usually, a characteristic crystal form.

**Monolith** (a) A piece of unfractured bedrock, generally more than a few meteres across; (b) A large upstanding mass of rock.

**Moraine** A mound, ridge, or other distinct accumulation of glacial drift, predominantly till, deposited in a variety of topographic landforms that are independent of control by the surface on which the drift lies.

**Morphology** The scientific study of form, and of the structures and development that influence form; term used in most sciences.

**Natural gamma log** These logs are run in cased, uncased, air, or water-filled boreholes. Natural gamma radiation increases from the left to the right side of the log. In marine sediments, low radiation levels indicate non-argillaceous limestone, dolomite, and sandstone.

**Nickpoint** A place of abrupt inflection in a stream profile; A sharp angle cut by currents at base of a cliff.

**Nonconformity** An unconformity resulting from deposition of sedimentary strata on massive crystalline rock.

**Outwash** Stratified drift (clay, silt, sand, gravel) that was deposited by meltwater streams in channels, deltas, outwash plains, on floodplains, and in glacial lakes.

**Outwash plain** The surface of a broad body of outwash formed in front of a glacier.

**Oxbow** lake A crescent-shaped lake in an abandoned bend of a river channel.

**Pangea** A hypothetical supercontinent; supposed by many geologists to have existed at an early time in the geologic past, and to have combined all the continental crust of the Earth, from which the present continents were derived by fragmentation and movement away from each other by means of some form of continental displacement. During an intermediate stage of the fragmentation, between the existence of Pangea and that of the present widely separated continents, Pangea was supposed to have split into two large fragments, Laurasia on the north and Gondwana on the south. The proto-ocean around Pangea has been termed Panthalassa. Other geologists, while believing in the former existence of Laurasia and Gondwana, are reluctant to concede the existence of an original Pangea; in fact, the early (Paleozoic or older) history of continental displacement remains largely undeciphered.

**Ped** A naturally formed unit of soil structure, e.g. granule, block, crumb, or aggregate.

**Peneplain** A land surface of regional proportions worn down by erosion to a nearly flat or broadly undulating plain.

**Period** An interval of geologic time; a division of an era.

**Physiography** The study and classification of the surface features of Earth on the basis of similarities in geologic strucure and the history of geologic changes.

**Physiographic province (or division)** (1) A region, all parts of which are similar in geologic structure and climate and which has consequently had a unified geologic history; (2) a region whose pattern of relief features or landforms differs significantly from that of adjacent regions.

**Point bar** A low arcuate ridge of sand and gravel developed on the inside of a stream meander by slow accumulation of sediment as the stream channel migrates toward the outer bank.

**Radioactivity logs** Logs of bore holes obtained through the use of gamma logging, neutron logging, or combinations of the several radioactivity logging methods.

**Relief** (a) A term used loosely for the actual physical shape, configuration, or general unevenness of a part of Earth's surface, considered with reference to variations of height and slope or to irregularities of the land surface; the elevations or differences in elevation, considered collectively,

of a land surface (frequently confused with topography). (b) The vertical difference in elevation between the hilltops or mountain summits and the lowlands or valleys of a given region; high relief has great variation; low relief has little variation.

**Sediment** Solid fragmental material, either inorganic or organic, that originates from weathering of rocks and is transported by, suspended in, or deposited by air, water, or ice, or that is accumulated by other natural agents, such as chemical precipitation from solution or secretion from organisms, and that forms in layers on Earth's surface at ordinary temperatures in a loose, unconsolidated form; e.g, sand, gravel, silt, mud, till, loess, alluvium.

**Sedimentary rock** A rock resulting from the consolidation of loose sediment that has accumulated in layers (e.g., sandstone, siltstone,limestone).

**Shoaling** The effect of a near-costal sea bottom on wave height; it descibes the alteration of a wave as it proceeds from deep water into shallow water. The wave height increases as the wave arrives on shore.

**Sinkholes** Small circular depressions that have formed by solution in areas underlain by soluble rocks, most commonly limestone and dolomite.

**Slip-off slope** Long, low, gentle slope on the inside of a stream meander.

**Stage, substage** Geologic time-rock units; the strata formed during an age or subage, respectively.

**Stratigraphy** The study, definition, and description of major and minor natural divisions of rocks, especially the study of the form, arrangement, geographic distribution, chronologic succession, classification, correlation, and mutual relationships of rock strata.

**Stratigraphic unit** A stratum or body of strata recognized as a unit in the classification of the rocks of Earth's crust with respect to any specific rock character, property, or attribute or for any purpose such as description, mapping, and correlation.

**Stratum** A tabular or sheet-like mass, or a single and distinct layer, of homogeneous or gradational sedimentary material of any thickness, visually separable from other layers above and below by a discrete change in character of the material deposited or by a sharp physical break in deposition, or by both; a sedimentary bed.

**Subage** An interval of geologic time; a division of an age.

**Syncline** A downfold of strata which dip inward from the sides toward the axis; youngest rocks along the axis; the opposite of anticline.

**System** The largest and fundamental geologic time-rock unit; the strata of a system were deposited during a period of geologic time.

**Tectonic** Pertaining to the global forces involved in, or the resulting structures or features of Earth's movements.

**Tectonics** The branch of geology dealing with the broad architecture of the upper (outer) part of Earth's crust; a regional assembling of structural or deformational features, their origins, historical evolution, and mutual relations.

**Temperature-resistance log** This log, run only in water, portrays the earth's temperature and the quality of groundwater in the well.

**Terrace** An abandoned floodplain formed when a stream flowed at a level above the level of its present channel and floodplain.

**Till** Unconsolidated, nonsorted, unstratified drift deposited by and underneath a glacier and consisting of a heterogenous mixture of different sizes and kinds of rock fragments.

**Till plain** The undulating surface of low relief in the area underlain by ground moraine.

**Topography** The natural or physical surface features of a region, considered collectively as to form; the features revealed by the contour lines of a map.

**Unconformable** Having the relation of an unconformity to underlying rocks and separated from them by an interruption in sedimentation, with or without any accompanying erosion of older rocks.

**Unconformity** A surface of erosion or nondeposition that separates younger strata from older strata; most unconformities indicate intervals of time when former areas of the sea bottom were temporarily raised above sea level.

**Valley trains** The accumulations of outwash deposited by rivers in their valleys downstream from a glacier.

**Water table** The upper surface of a zone of saturation.

**Weathering** The group of processes, chemical and physical, whereby rocks on exposure to the weather change in character, decay, and finally crumble into soil.

# DEPOSITIONAL HISTORY OF THE PENNSYLVANIAN ROCKS IN ILLINOIS

At the close of the Mississippian Period, about 310 million years ago, the sea withdrew from the Midcontinent region. A long interval of erosion that took place early in Pennsylvanian time removed hundreds of feet of the pre-Pennsylvanian strata, completely stripping them away and cutting into older rocks over large areas of the Midwest. Ancient river systems cut deep channels into the bedrock surface. Later, but still during early Pennsylvanian (Morrowan) time, the sea level started to rise; the corresponding rise in the base level of deposition interrupted the erosion and led to filling the valleys in the erosion surface with fluvial, brackish, and marine sands and muds.

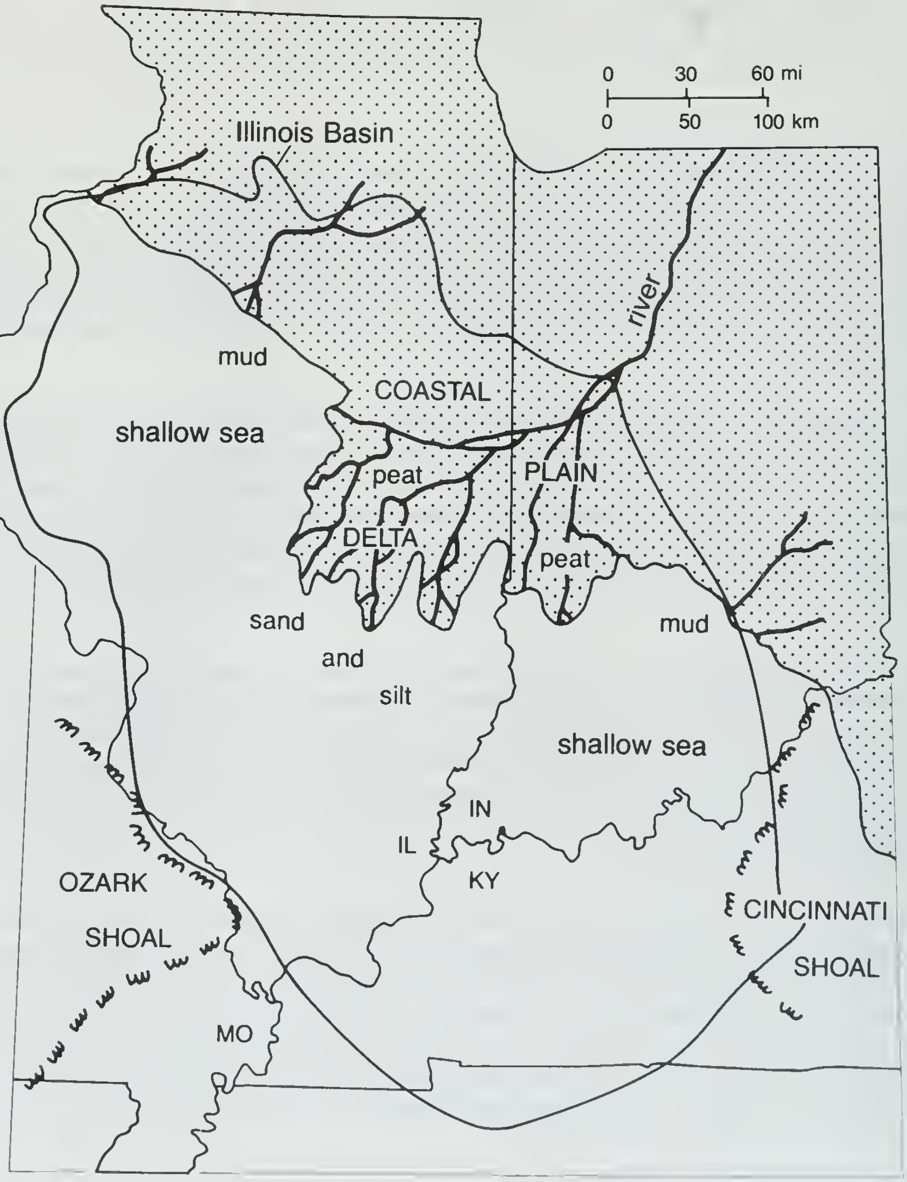
Depositional conditions in the Illinois Basin during the Pennsylvanian Period were somewhat similar to those of the preceding Chesterian (late Mississippian) time. A river system flowed southwestward across a swampy lowland, carrying mud and sand from highlands to the northeast. This river system formed thin but widespread deltas that coalesced into a vast coastal plain or lowland that prograded (built out) into the shallow sea that covered much of present-day Illinois (see paleogeographic map, next page). As the lowland stood only a few feet above sea level, slight changes in relative sea level caused great shifts in the position of the shoreline.

During most of Pennsylvanian time, the Illinois Basin gradually subsided; a maximum of about 3000 feet of Pennsylvanian sediments are preserved in the basin. The locations of the delta systems and the shoreline of the resulting coastal plain shifted, probably because of worldwide sea level changes, coupled with variation in the amounts of sediments provided by the river system and local changes in basin subsidence rates. These frequent shifts in the coastline position caused the depositional conditions at any one locality in the basin to alternate frequently between marine and nonmarine, producing a variety of lithologies in the Pennsylvanian rocks (see lithology distribution chart).

Conditions at various places on the shallow sea floor favored the deposition of sand, lime mud, or mud. Sand was deposited near the mouths of distributary channels, where it was reworked by waves and spread out as thin sheets near the shore. Mud was deposited in quiet-water areas — in delta bays between distributaries, in lagoons behind barrier bars, and in deeper water beyond the nearshore zone of sand deposition. Limestone was formed from the accumulation of limy parts of plants and animals laid down in areas where only minor amounts of sand and mud were being deposited. The areas of sand, mud, and limy mud deposition continually changed as the position of the shoreline changed and as the delta distributaries extended seaward or shifted their positions laterally along the shore.

Nonmarine sand, mud, and lime mud were deposited on the coastal plain bordering the sea. The nonmarine sand was deposited in delta distributary channels, in river channels, and on the broad floodplains of the rivers. Some sand bodies 100 or more feet thick were deposited in channels that cut through the underlying rock units. Mud was deposited mainly on floodplains. Some mud and freshwater lime mud were deposited locally in fresh-water lakes and swamps.

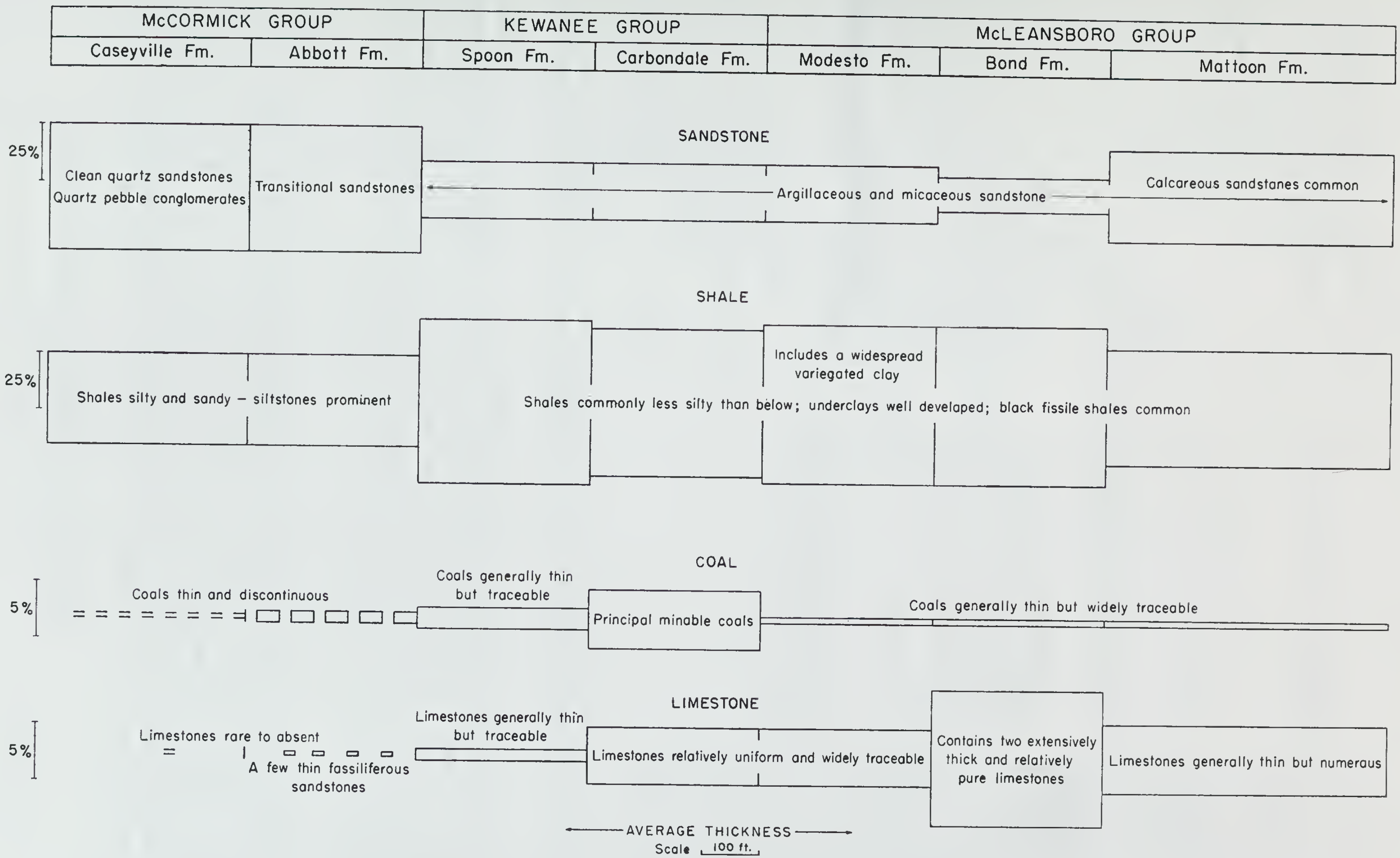
Beneath the quiet water of extensive swamps that prevailed for long intervals on the emergent coastal lowland, peat was formed by accumulation of plant material. Lush forest vegetation covered the region; it thrived in the warm, moist Pennsylvanian-age climate. Although the origin of the underclays beneath the coal is not precisely known, most evidence indicates that they were deposited in the swamps as slackwater mud before the accumulation of much plant debris. The clay underwent modification to become the soil upon which the lush vegetation grew in the swamps. Underclay frequently contains plant roots and rootlets that appear to be in their original places. The vast swamps were the culmination of nonmarine deposition. Resubmergence of the borderlands by the sea interrupted nonmarine deposition, and marine sediments were laid down over the peat.



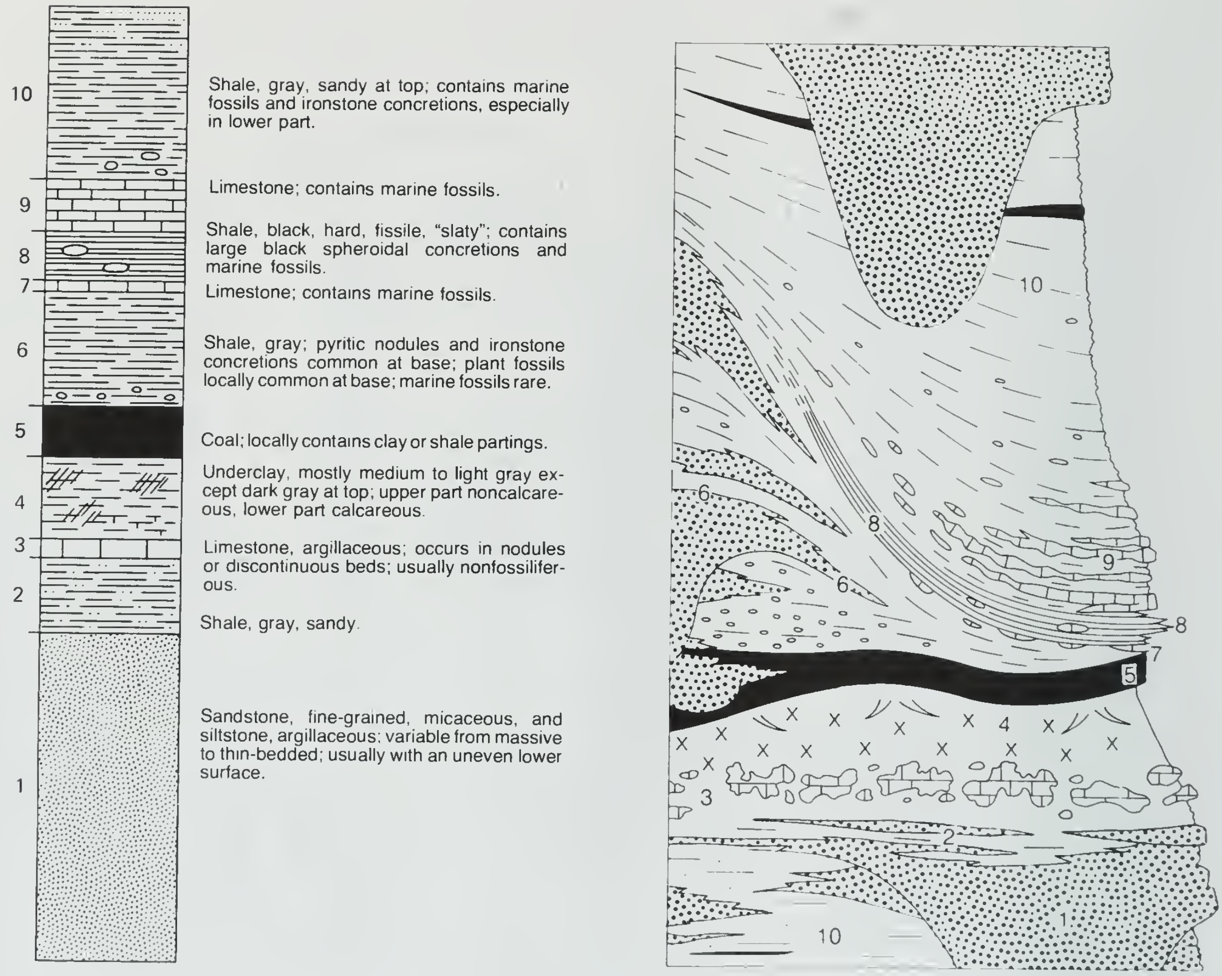

Paleogeography of Illinois-Indiana region during Pennsylvanian time. The diagram shows a Pennsylvanian river delta and the position of the shoreline and the sea at an instant of time during the Pennsylvanian Period.

## Pennsylvanian Cyclothems

The Pennsylvanian strata exhibit extraordinary variations in thickness and composition both laterally and vertically because of the extremely varied environmental conditions under which they formed. Individual sedimentary units are often only a few inches thick and rarely exceed 30 feet thick. Sandstones and shales commonly grade laterally into each other, and shales sometimes interfinger and grade into limestones and coals. The underclays, coals, black shales, and some limestones, however, display remarkable lateral continuity for such thin units. Coal seams have been traced in mines, outcrops, and subsurface drill records over areas comprising several states.



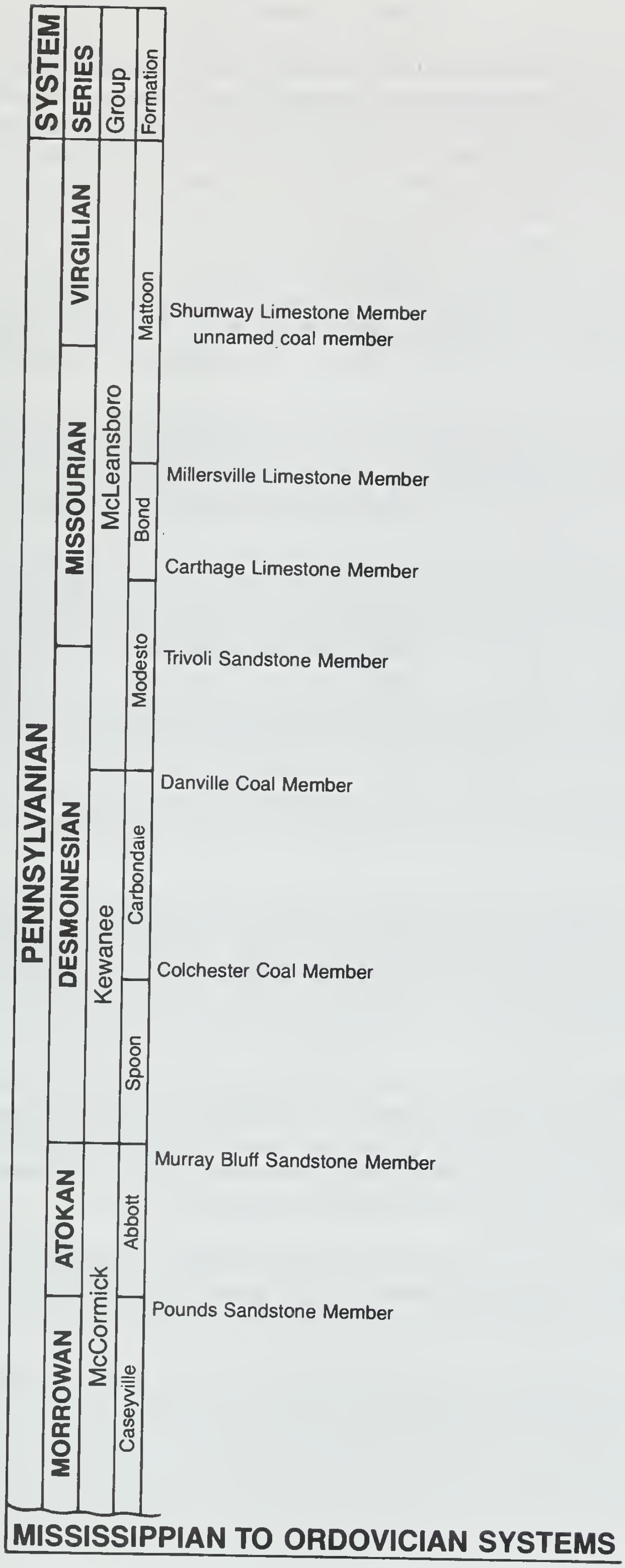

General distribution of the four principal lithologies in Pennsylvanian strata of Illinois.




The idealized cyclothem at left (after Willman and Payne, 1942) infers continuous, widespread distribution of individual cyclothem units, at right the model of a typical cyclothem (after Baird and Shabica, 1980) shows the discontinuous nature of many units in a cyclothem.

The rapid and frequent changes in depositional environments during Pennsylvanian time produced regular or cyclical alternations of sandstone, shale, limestone, and coal in response to the shifting shoreline. Each series of alternations, called a cyclothem, consists of several marine and nonmarine rock units that record a complete cycle of marine invasion and retreat. Geologists have determined, after extensive studies of the Pennsylvanian strata in the Midwest, that an "ideally" complete cyclothem consists of ten sedimentary units (see illustration above contrasting the model of an "ideal" cyclothem with a model showing the dynamic relationships between the various members of a typical cyclothem).

Approximately 50 cyclothems have been described in the Illinois Basin but only a few contain all ten units at any given location. Usually one or more are missing because conditions of deposition were more varied than indicated by the "ideal" cyclothem. However, the order of units in each cyclothem is almost always the same: a typical cyclothem includes a basal sandstone overlain by an underclay, coal, black sheety shale, marine limestone, and gray marine shale. In general, the sandstone-underclay-coal-gray shale portion (the lower six units) of each cyclothem is nonmarine: it was deposited as part of the coastal lowlands from which the sea had withdrawn. However, some of the sandstones are entirely or partly marine. The units above the coal and gray shale are marine sediments deposited when the sea advanced over the coastal plain.




Generalized stratigraphic column of the Pennsylvanian in Illinois (1 inch = approximately 250 feet).

## Origin of Coal

It is generally accepted that the Pennsylvanian coals originated by the accumulation of vegetable matter, usually in place, beneath the waters of extensive, shallow, fresh-to-brackish swamps. They represent the last-formed deposits of the nonmarine portions of the cyclothems. The swamps occupied vast areas of the coastal lowland, which bordered the shallow Pennsylvanian sea. A luxuriant growth of forest plants, many quite different from the plants of today, flourished in the warm, humid Pennsylvanian climate. (Illinois at that time was near the equator.) The deciduous trees and flowering plants that are common today had not yet evolved. Instead, the jungle-like forests were dominated by giant ancestors of present-day club mosses, horsetails, ferns, conifers, and cycads. The undergrowth also was well developed, consisting of many ferns, fernlike plants, and small club mosses. Most of the plant fossils found in the coals and associated sedimentary rocks show no annual growth rings, suggesting rapid growth rates and lack of seasonal variations in the climate (tropical). Many of the Pennsylvanian plants, such as the seed ferns, eventually became extinct.

Plant debris from the rapidly growing swamp forests — leaves, twigs, branches, and logs — accumulated as thick mats of peat on the floors of the swamps. Normally, vegetable matter rapidly decays by oxidation, forming water, nitrogen, and carbon dioxide. However, the cover of swamp water, which was probably stagnant and low in oxygen, prevented oxidation, and any decay of the peat deposits was due primarily to bacterial action.

The periodic invasions of the Pennsylvanian sea across the coastal swamps killed the Pennsylvanian forests, and the peat deposits were often buried by marine sediments. After the marine transgressions, peat usually became saturated with sea water containing sulfates and other dissolved minerals. Even the marine sediments being deposited on the top of the drowned peat contained various minerals in solution, including sulfur, which further infiltrated the peat. As a result, the peat developed into a coal that is high in sulfur. However, in a number of areas, nonmarine muds, silts, and sands from the river system on the coastal plain covered the peat where flooding broke through levees or the river changed its coarse. Where these sediments (unit 6 of the cyclothem) are more than 20 feet thick, we find that the coal is low in sulfur, whereas coal found directly beneath marine rocks is high in sulfur. Although the seas did cover the areas where these nonmarine, fluvial sediments covered the peat, the peat was protected from sulfur infiltration by the shielding effect of these thick fluvial sediments.

Following burial, the peat deposits were gradually transformed into coal by slow physical and chemical changes in which pressure (compaction by the enormous weight of overlying sedimentary layers), heat (also due to deep burial), and time were the most important factors. Water and volatile substances (nitrogen, hydrogen, and oxygen) were slowly driven off during the coal-forming ("coalification") process, and the peat deposits were changed into coal.

Coals have been classified by ranks that are based on the degree of coalification. The commonly recognized coals, in order of increasing rank, are (1) brown coal or lignite, (2) sub-bituminous, (3) bituminous, (4) semibituminous, (5) semianthracite, and (6) anthracite. Each increase in rank is characterized by larger amounts of fixed carbon and smaller amounts of oxygen and other volatiles. Hardness of coal also increases with increasing rank. All Illinois coals are classified as bituminous.

Underclays occur beneath most of the coals in Illinois. Because underclays are generally unstratified (unlayered), are leached to a bleached appearance, and generally contain plant roots, many geologists consider that they represent the ancient soils on which the coal-forming plants grew.

The exact origin of the carbonaceous black shale that occurs above many coals is uncertain. Current thinking suggests that the black shale actually represents the deepest part of the marine transgression. Maximum transgression of the sea, coupled with upwelling of ocean water and accumulation of mud and animal remains on an anaerobic ocean floor, led to the deposition of black organic mud over vast areas stretching from Texas to Illinois. Deposition occurred in quiet-water areas where the very fine-grained iron-rich

mud and finely divided plant debris were washed in from the land. Most of the fossils found in black shale represent planktonic (floating) and nektonic (swimming) forms — not benthonic (bottom-dwelling) forms. The depauperate (dwarf) fossil forms sometimes found in black shale formerly were thought to have been forms that were stunted by toxic conditions in the sulfide-rich, oxygen-deficient water of the lagoons. However, study has shown that the "depauperate" fauna consists mostly of normal-size individuals of species that never grew any larger.

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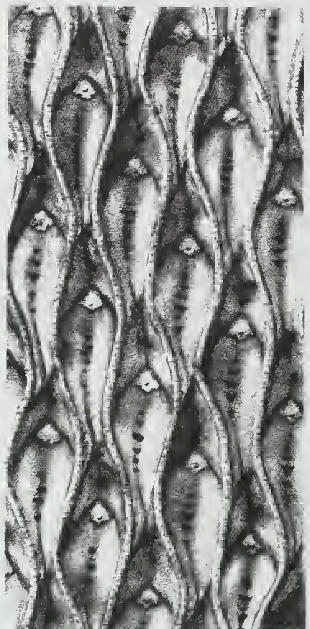
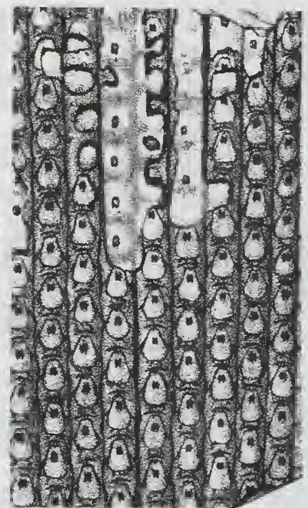
## Common Pennsylvanian plants: lycopods, sphenophytes, and ferns

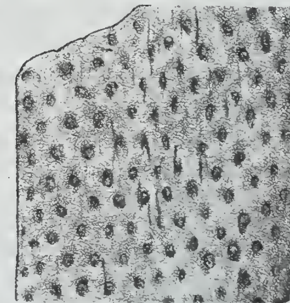


*Lepidodendron aculeatum* X0.8

*Lepidophloios laricinus* X0.63

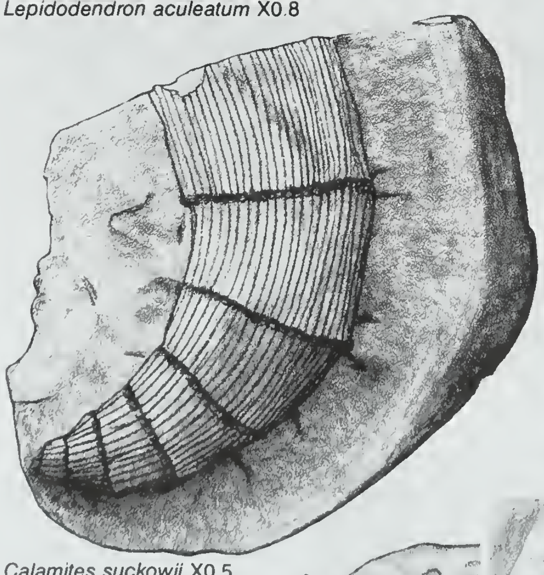


*Sigillaria mammilaris* X0.5

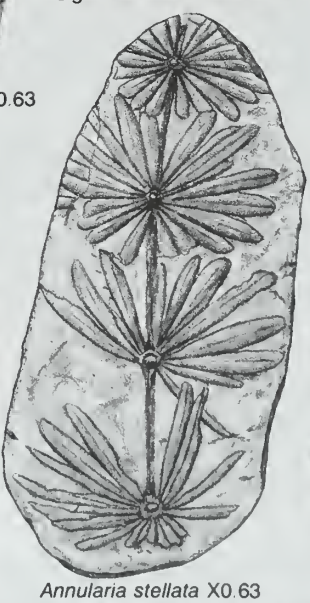


*Stigmaria ficoides* X0.32

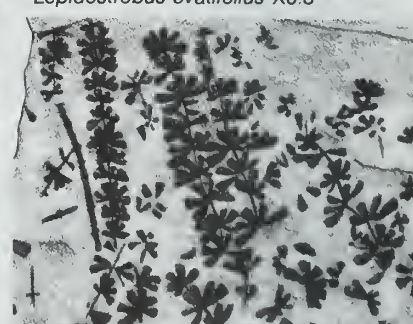
*Lepidostrobus ovatifolius* X0.8



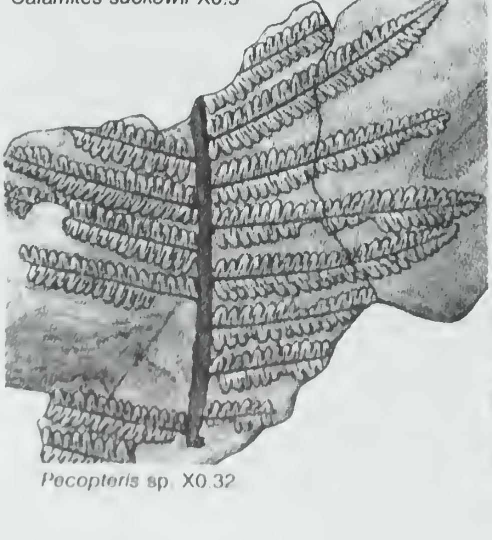
*Calamites suckowii* X0.5



*Annularia stellata* X0.63

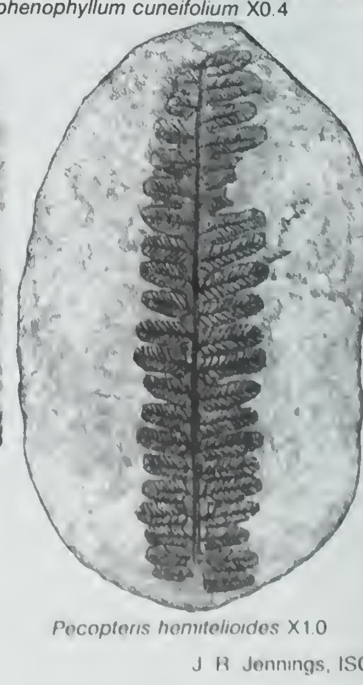


*Sphenophyllum cuneifolium* X0.4



*Pecopteris* sp. X0.32

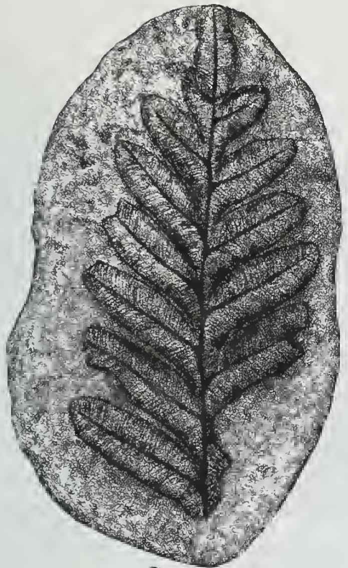
*Pecopteris miltonii* X2.0

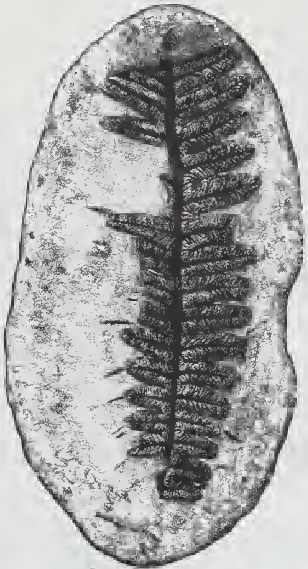


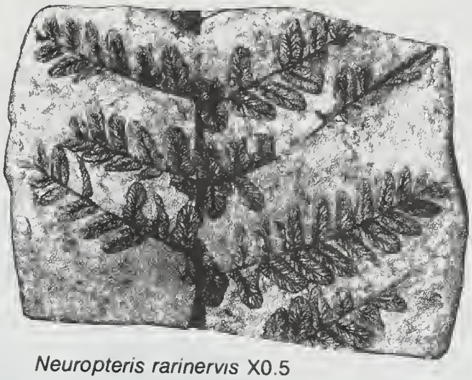
*Pecopteris hemitelioides* X1.0

J R Jennings, ISGS

## Common Pennsylvanian plants: seed ferns and cordaiteans


*Alethopteris serlii* X0.63

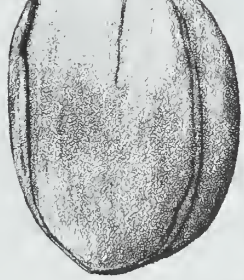

*Alethopteris ambigua* X0.63


*Neuropteris rarinervis* X0.5


*Mariopteris nervosa* X0.8

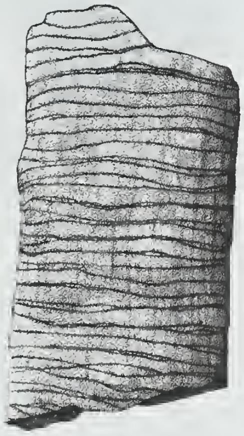

*Neuropteris scheuchzeri* X0.63


*Sphenopteris rotundiloba* X0.8


*Trigonocarpus parkinsonii* X1.25

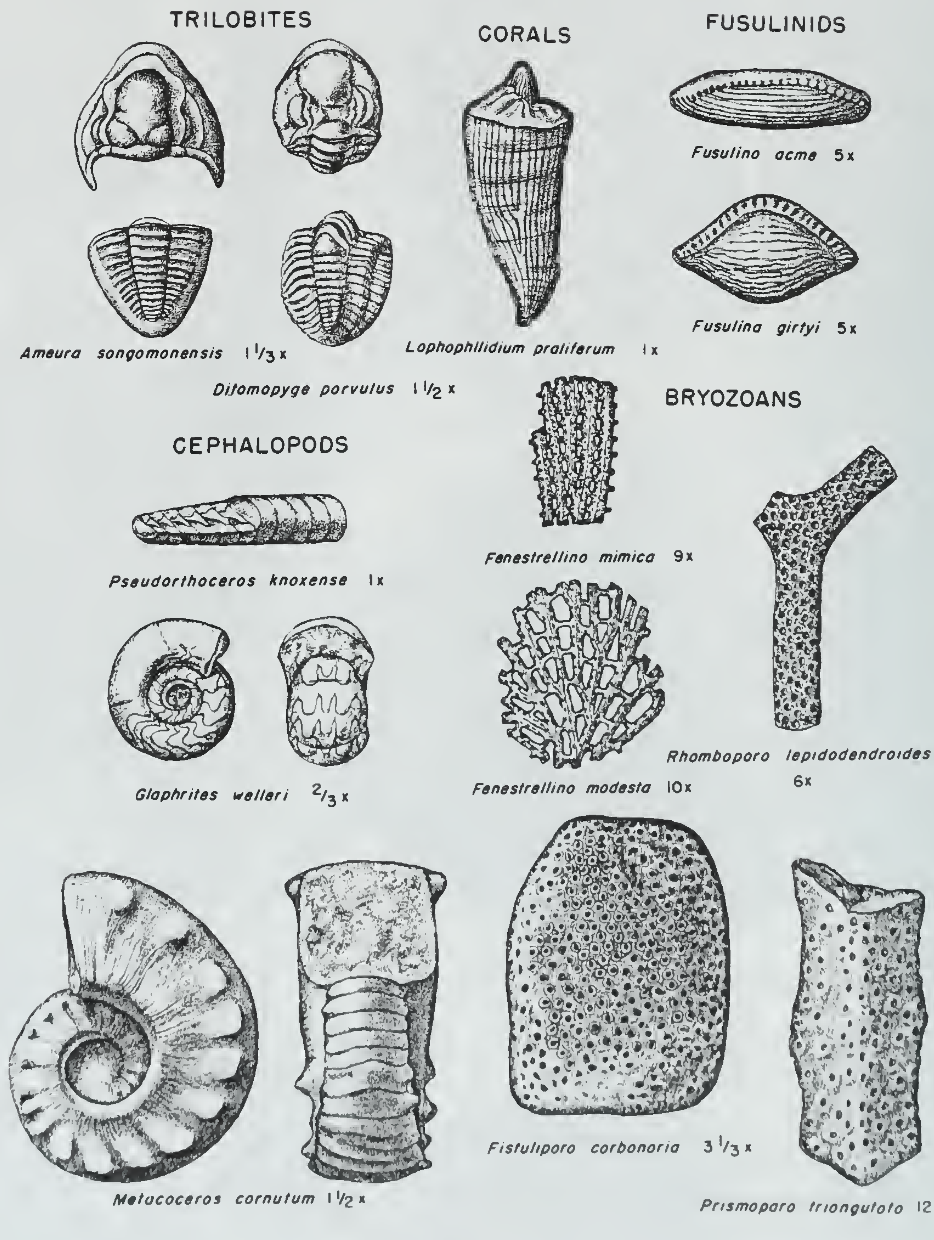

*Cordaites principalis* X0.63


*Cordaicladus* sp. X1.0


*Artisia transversa* X0.63


*Cordaicarpon major* X2.0

J. R. Jennings, ISGS


TRILOBITES
CORALS
FUSULINIDS
Fusulino acme 5x
Fusulina girtyi 5x
Ameura songomonensis $1\frac{1}{3}$x
Lophophllidium proliferum 1x
Ditomopyge porvulus $1\frac{1}{2}$x
BRYOZOANS
CEPHALOPODS
Pseudorthoceros knoxense 1x
Fenestrellino mimica 9x
Glaphrites welleri $\frac{2}{3}$x
Fenestrellino modesta 10x
Rhomboporo lepidodendroides 6x
Fistuliporo corbonoria $3\frac{1}{3}$x
Metococeros cornutum $1\frac{1}{2}$x
Prismoporo triongutoto 12x

## PELECYPODS

*Nucula (Nuculopsis) girtyi* 1x

*Edmonia ovata* 2x

*Astartella concentrica* 1x

*Dunbarella knighti* 1½x

*Cardiomorpha missouriensis*
"Type A" 1x

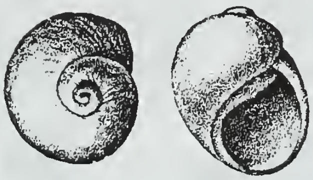
*Cardiomorpha missouriensis*
"Type B" 1½x

## GASTROPODS

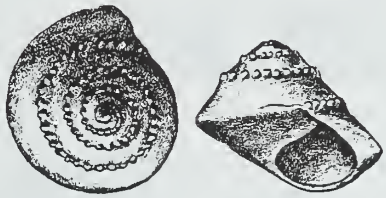
*Euphemites carbonarius* 1½x

*Trepospira illinoisensis* 1½x

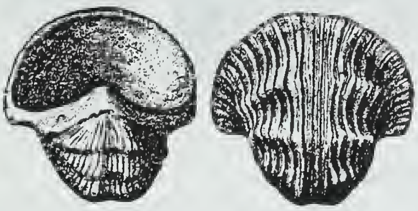
*Donaldina robusta* 8x



*Naticopsis (Jedria) ventricosa* 1½x



*Trepaspira sphaerulata* 1x



*Knightites montfortianus* 2x

*Glabrocingulum (Glabrocingulum) grayvillense* 3x

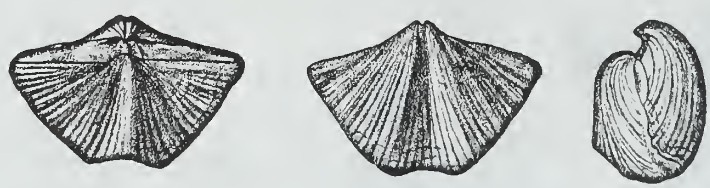
## BRACHIOPODS

*Juresania nebrascensis* 2/3 x

*Wellerella tetrahedra* 1 1/2 x

*Derbya crassa* 1x

*Composita argentia* 1x



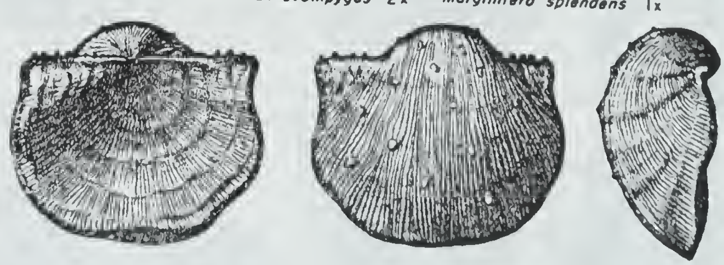
*Neospirifer cameratus* 1x

*Chonetes granulifer* 1 1/2 x

*Mesolobus mesolobus* var. *euampygus* 2 x

*Marginifera splendens* 1x

*Crurithyris planoconvexa* 2 x



*Linoproductus "cora"* 1x

# PLEISTOCENE GLACIATIONS IN ILLINOIS

## Origin of the Glaciers

During the past million years or so, an interval of time called the Pleistocene Epoch, most of the northern hemisphere above the 50th parallel has been repeatedly covered by glacial ice. The cooling of the earth's surface, a prerequisite for glaciation, began at least 2 million years ago. On the basis of evidence found in subpolar oceans of the world (temperature-dependent fossils and oxygen-isotope ratios), a recent proposal has been made to recognize the beginning of the Pleistocene at 1.6 million years ago. Ice sheets formed in sub-arctic regions many times and spread outward until they covered the northern parts of Europe and North America. In North America, early studies of the glacial deposits led to the model that four glaciations could explain the observed distribution of glacial deposits. The deposits of a glaciation were separated from each other by the evidence of intervals of time during which soils formed on the land surface. In order of occurrence from the oldest to the youngest, they were given the names Nebraskan, Kansan, Illinoian, and Wisconsinan Stages of the Pleistocene Epoch. Work in the last 30 years has shown that there were more than four glaciations but the actual number and correlations at this time are not known. Estimates that are gaining credibility suggest that there may have been about 14 glaciations in the last one million years. In Illinois, estimates range from 4 to 8 based on buried soils and glacial deposits. For practical purposes, the previous four glacial stage model is functional, but we now know that the older stages are complex and probably contain more than one glaciation. Until we know more, all of the older glacial deposits, including the Nebraskan and Kansan will be classified as pre-Illinoian. The limits and times of the ice movement in Illinois are illustrated in the following pages by several figures.

The North American ice sheets developed when the mean annual temperature was perhaps 4° to 7°C (7° to 13°F) cooler than it is now and winter snows did not completely melt during the summers. Because the time of cooler conditions lasted tens of thousands of years, thick masses of snow and ice accumulated to form glaciers. As the ice thickened, the great weight of the ice and snow caused them to flow outward at their margins, often for hundreds of miles. As the ice sheets expanded, the areas in which snow accumulated probably also increased in extent.

Tongues of ice, called lobes, flowed southward from the Canadian centers near Hudson Bay and converged in the central lowland between the Appalachian and Rocky Mountains. There the glaciers made their farthest advances to the south. The sketch below shows several centers of flow, the general directions of flow from the centers, and the southern extent of glaciation. Because Illinois lies entirely in the central lowland, it has been invaded by glaciers from every center.

## Effects of Glaciation

Pleistocene glaciers and the waters melting from them changed the landscapes they covered. The glaciers scraped and smeared the landforms they overrode, leveling and filling many of the minor valleys and even some of the larger ones. Moving ice carried colossal amounts of rock and earth, for much of what the glaciers wore off the ground was kneaded into the moving ice and carried along, often for hundreds of miles.

The continual floods released by melting ice entrenched new drainageways, deepened old ones, and then partly refilled both with sediments as great quantities of rock and earth were carried beyond the glacier fronts. According to some estimates, the amount of water drawn from the sea and changed into ice during a glaciation was enough to lower the sea level from 300 to 400 feet below present level. Consequently, the melting of a continental ice sheet provided a tremendous volume of water that eroded and transported sediments.

In most of Illinois, then, glacial and meltwater deposits buried the old rock-ribbed, low, hill-and-valley terrain and created the flatter landforms of our prairies. The mantle of soil material and the buried deposits of gravel, sand, and clay left by the glaciers over about 90 percent of the state have been of incalculable value to Illinois residents.

## Glacial Deposits

The deposits of earth and rock materials moved by a glacier and deposited in the area once covered by the glacier are collectively called **drift**. Drift that is ice-laid is called **till**. Water-laid drift is called **outwash**.

Till is deposited when a glacier melts and the rock material it carries is dropped. Because this sediment is not moved much by water, a till is unsorted, containing particles of different sizes and compositions. It is also stratified (unlayered). A till may contain materials ranging in size from microscopic clay particles to large boulders. Most tills in Illinois are pebbly clays with only a few boulders. For descriptive purposes, a mixture of clay, silt, sand and boulders is called **diamicton**. This is a term used to describe a deposit that could be interpreted as till or a mass wasting product.

Tills may be deposited as **end moraines**, the arc-shaped ridges that pile up along the glacier edges where the flowing ice is melting as fast as it moves forward. Till also may be deposited as **ground moraines**, or **till plains**, which are gently undulating sheets deposited when the ice front melts back, or retreats. Deposits of till identify areas once covered by glaciers. Northeastern Illinois has many alternating ridges and plains, which are the succession of end moraines and till plains deposited by the Wisconsinan glacier.

Sorted and stratified sediment deposited by water melting from the glacier is called **outwash**. Outwash is bedded, or layered, because the flow of water that deposited it varied in gradient, volume, velocity, and direction. As a meltwater stream washes the rock materials along, it sorts them by size—the fine sands, silts, and clays are carried farther downstream than the coarser gravels and cobbles. Typical Pleistocene outwash in Illinois is in multilayered beds of clays, silts, sands, and gravels that look much like modern stream deposits in some places. In general, outwash tends to be coarser and less weathered, and alluvium is most often finer than medium sand and contains variable amounts of weathered material.

Outwash deposits are found not only in the area covered by the ice field but sometimes far beyond it. Meltwater streams ran off the top of the glacier, in crevices in the ice, and under the ice. In some places, the cobble-gravel-sand filling of the bed of a stream that flowed in the ice is preserved as a sinuous ridge called an **esker**. Some eskers in Illinois are made up of sandy to silty deposits and contain mass wasted diamicton material. Cone-shaped mounds of coarse outwash, called **kames**, were formed where meltwater plunged through crevasses in the ice or into ponds on the glacier.

The finest outwash sediments, the clays and silts, formed bedded deposits in the ponds and lakes that filled glacier-dammed stream valleys, the sags of the till plains, and some low, moraine-diked till plains. Meltwater streams that entered a lake rapidly lost speed and also quickly dropped the sands and gravels they carried, forming deltas at the edge of the lake. Very fine sand and silts were commonly redistributed on the lake bottom by wind-generated currents, and the clays, which stayed in suspension longest, slowly settled out and accumulated with them.

Along the ice front, meltwater ran off in innumerable shifting and short-lived streams that laid down a broad, flat blanket of outwash that formed an **outwash plain**. Outwash was also carried away from the glacier in valleys cut by floods of meltwater. The Mississippi, Illinois, and Ohio Rivers occupy valleys that were major channels for meltwaters and were greatly widened and deepened during times of the greatest meltwater floods. When the floods waned, these valleys were partly filled with outwash far beyond the ice margins. Such outwash deposits, largely sand and gravel, are known as **valley trains**. Valley train deposits may be both extensive and thick. For instance, the long valley train of the Mississippi Valley is locally as much as 200 feet thick.

## Loess, Eolian Sand and Soils

One of the most widespread sediments resulting from glaciation was carried not by ice or water but by wind. **Loess** is the name given to windblown deposits dominated by silt. Most of the silt was derived from wind erosion of the valley trains. Wind action also sorted out **eolian sand** which commonly formed **sand dunes** on the valley trains or on the adjacent uplands. In places, sand dunes have migrated up to 10 miles away from the principle source of sand. Flat areas between dunes are generally underlain by eolian **sheet sand** that is commonly reworked by water action. On uplands along the major valley trains, loess and eolian sand are commonly interbedded. With increasing distance from the valleys, the eolian sand pinches out, often within one mile.

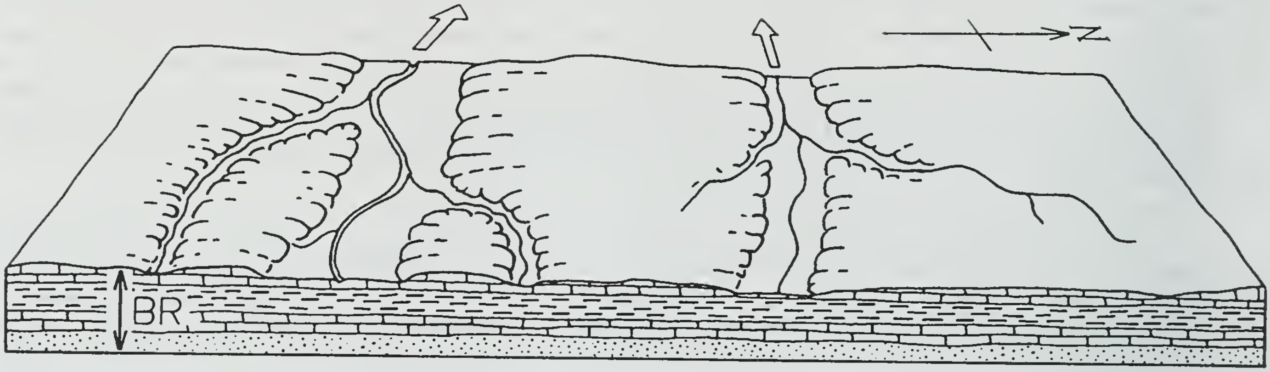
Eolian deposition occurred when certain climatic conditions were met, probably in a seasonal pattern. Deposition could have occurred in the fall, winter or spring season when low precipitation rates and low temperatures caused meltwater floods to abate, exposing the surfaces of the valley trains and permitting them to dry out. During Pleistocene time, as now, west winds prevailed, and the loess deposits are thickest on the east sides of the source valleys. The loess thins rapidly away from the valleys but extends over almost all the state.

Each Pleistocene glaciation was followed by an interglacial stage that began when the climate warmed enough to melt the glaciers and their snowfields. During these warmer intervals, when the climate was similar to that of today, drift and loess surfaces were exposed to weather and the activities of living things. Consequently, over most of the glaciated terrain, soils developed on the Pleistocene deposits and altered their composition, color, and texture. Such soils were generally destroyed by later glacial advances, but some were buried. Those that survive serve as "key beds," or stratigraphic markers, and are evidence of the passage of a long interval of time.

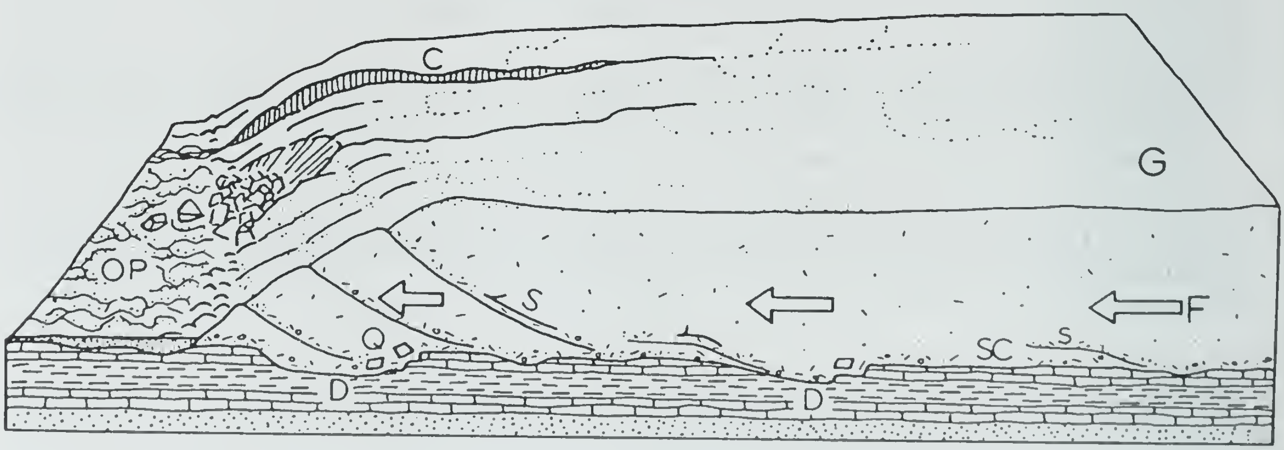
## Glaciation in a Small Illinois Region

The following diagrams show how a continental ice sheet might have looked at various stages as it moved across a small region in Illinois. They illustrate how it could change the old terrain and create a landscape like the one we live on. To visualize how these glaciers looked, geologists study the landforms and materials left in the glaciated regions and also the present-day mountain glaciers and polar ice caps.

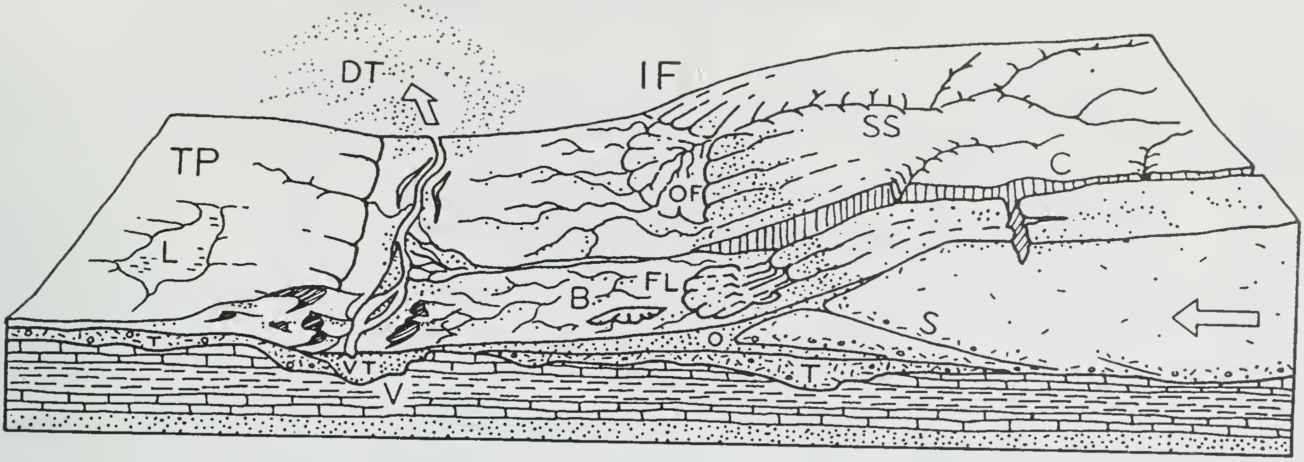
The block of land in the diagrams is several miles wide and about 10 miles long. The vertical scale is exaggerated—layers of material are drawn thicker and landforms higher than they ought to be so that they can be easily seen.




1. **The Region Before Glaciation** — Like most of Illinois, the region illustrated is underlain by almost flat-lying beds of sedimentary rocks—layers of sandstone ( ), limestone ( ), and shale ( ). Millions of years of erosion have planed down the bedrock (BR), creating a terrain of low uplands and shallow valleys. A residual soil weathered from local rock debris covers the area but is too thin to be shown in the drawing. The streams illustrated here flow westward and the one on the right flows into the other at a point beyond the diagram.



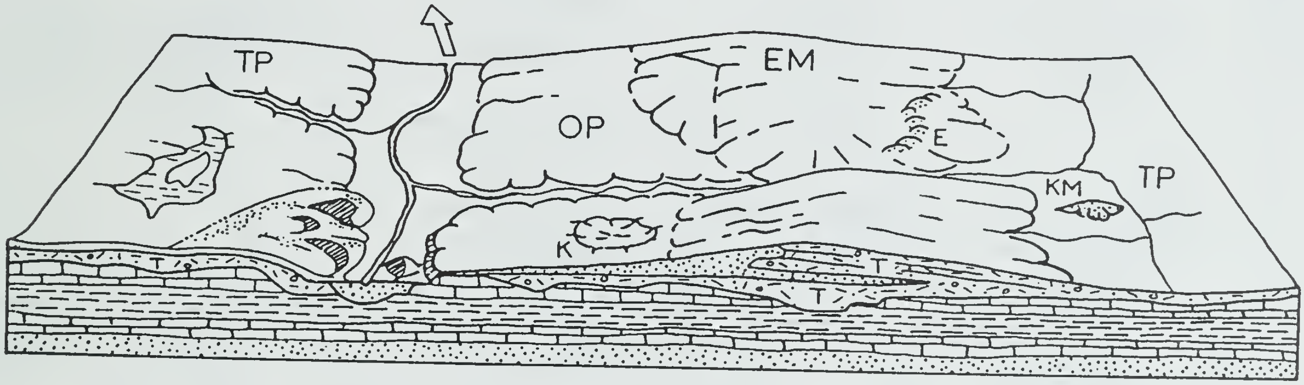

2. **The Glacier Advances Southward** — As the Glacier (G) spreads out from its ice snowfield accumulation center, it scours (SC) the soil and rock surface and quarries (Q)—pushes and plucks up—chunks of bedrock. The materials are mixed into the ice and make up the glacier's "load." Where roughnesses in the terrain slow or stop flow (F), the ice "current" slides up over the blocked ice on innumerable shear planes (S). Shearing mixes the load very thoroughly. As the glacier spreads, long cracks called "crevasses" (C) open parallel to the direction of ice flow. The glacier melts as it flows forward, and its meltwater erodes the terrain in front of the ice, deepening (D) some old valleys before ice covers them. Meltwater washes away some of the load freed by melting and deposits it on the outwash plain (OP). The advancing glacier overrides its outwash and in places scours much of it up again. The glacier may be 5000 or so feet thick, and tapers to the margin, which was probably in the range of several hundred feet above the old terrain. The ice front advances perhaps as much as a third of a mile per year.




3. **The Glacier Deposits an End Moraine** — After the glacier advances across the area, the climate warms and the ice begins to melt as fast as it advances. The ice front (IF) is now stationary, or fluctuating in a narrow area, and the glacier is depositing an end moraine.

As the top of the glacier melts, some of the sediment that is mixed in the ice accumulates on top of the glacier. Some is carried by meltwater onto the sloping ice front (IF) and out onto the plain beyond. Some of the debris slips down the ice front in a mudflow (FL). Meltwater runs through the ice in a crevasse (C). A supraglacial stream (SS) drains the top of the ice, forming an outwash fan (OF). Moving ice has overridden an immobile part of the front on a shear plane (S). All but the top of a block of ice (B) is buried by outwash (O).

Sediment from the melted ice of the previous advance (figure 2) remains as a till layer (T), part of which forms the till plain (TP). A shallow, marshy lake (L) fills a low place in the plain. Although largely filled with drift, the valley (V) remains a low spot in the terrain. As soon as the ice cover melts, meltwater drains down the valley, cutting it deeper. Later, outwash partly refills the valley: the outwash deposit is called a valley train (VT). Wind blows dust (DT) off the dry floodplain. The dust will form a loess deposit when it settles. Sand dunes (D) form on the south and east sides of streams.




4. **The Region after Glaciation** — As the climate warms further, the whole ice sheet melts, and glaciation ends. The end moraine (EM) is a low, broad ridge between the outwash plain (OP) and till plains (TP). Run-off from rains cuts stream valleys into its slopes. A stream goes through the end moraine along the channel cut by the meltwater that ran out of the crevasse in the glacier.

Slopewash and vegetation are filling the shallow lake. The collapse of outwash into the cavity left by the ice block's melting has made a kettle (K). The outwash that filled a tunnel draining under the glacier is preserved in an esker (E). The hill of outwash left where meltwater dumped sand and gravel into a crevasse or other depression in the glacier or at its edge is a kame (KM). A few feet of loess covers the entire area but cannot be shown at this scale.

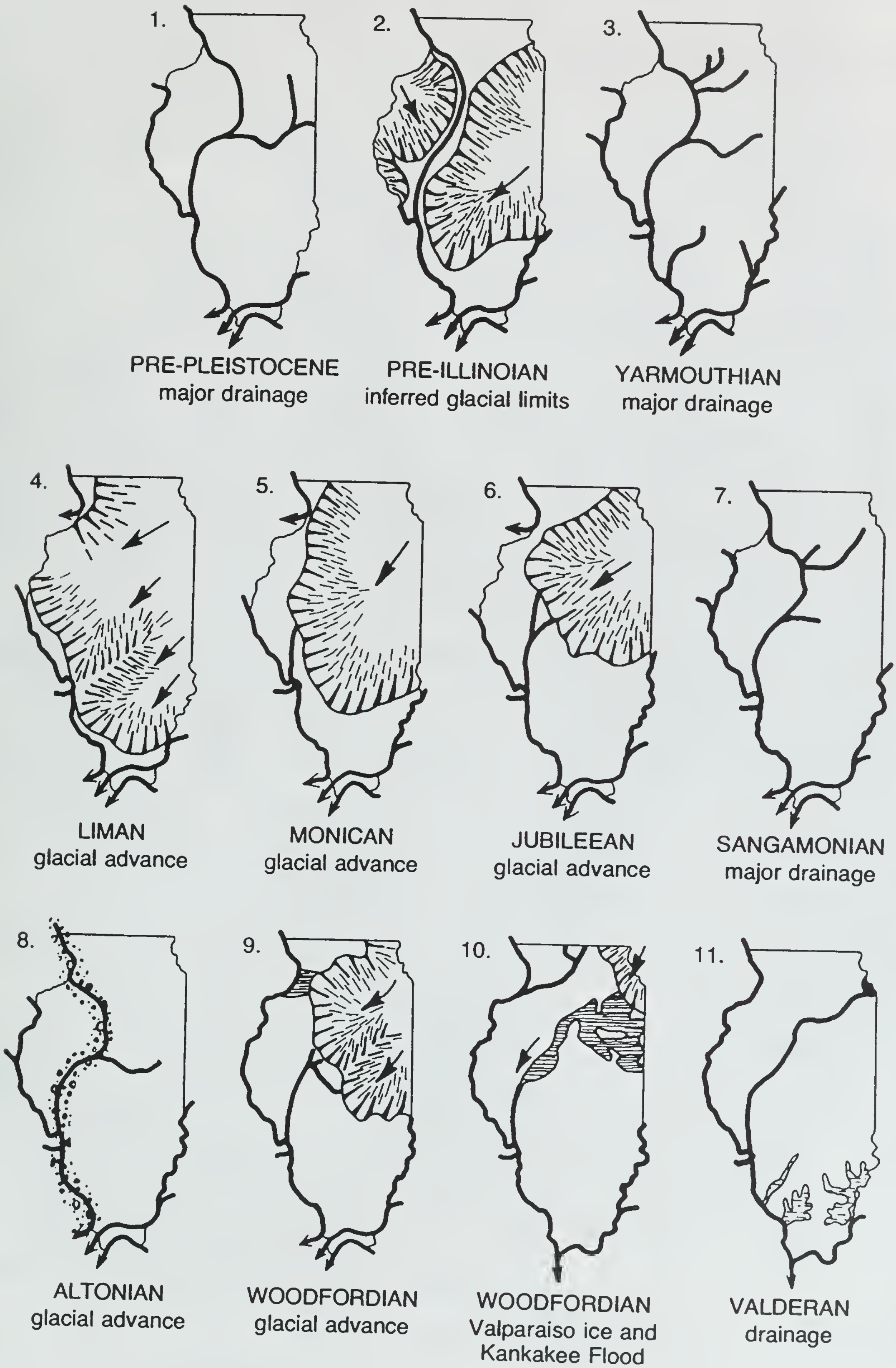
TIME TABLE OF PLEISTOCENE GLACIATION

| | | STAGE | | SUBSTAGE | NATURE OF DEPOSITS | SPECIAL FEATURES |
|---|---|---|---|---|---|---|
| QUATERNARY | | HOLOCENE (interglacial) | | Years Before Present | Soil, youthful profile of weathering, lake and river deposits, dunes, peat | |
| | | | | 10,000 | | |
| | Pleistocene | WISCONSINAN (glacial) | late | Valderan | Outwash, lake deposits | Outwash along Mississippi Valley |
| | | | | 11,000 | | |
| | | | | Twocreekan | Peat and alluvium | Ice withdrawal, erosion |
| | | | | 12,500 | | |
| | | | | Woodfordian | Drift, loess, dunes, lake deposits | Glaciation; building of many moraines as far south as Shelbyville; extensive valley trains, outwash plains, and lakes |
| | | | | 25,000 | | |
| | | | mid | Farmdalian | Soil, silt, and peat | Ice withdrawal, weathering, and erosion |
| | | | | 28,000 | | |
| | | | early | Altonian | Drift, loess | Glaciation in Great Lakes area, valley trains along major rivers |
| | | | | 75,000 | | |
| | | SANGAMONIAN (interglacial) | | | Soil, mature profile of weathering | Important stratigraphic marker |
| | | | | 125,000 | | |
| | | ILLINOIAN (glacial) | | Jubileean | Drift, loess, outwash | Glaciers from northeast at maximum reached Mississippi River and nearly to southern tip of Illinois |
| | | | | Monican | Drift, loess, outwash | |
| | | | | Liman | Drift, loess, outwash | |
| | | | | 300,000? | | |
| | | YARMOUTHIAN (interglacial) | | | Soil, mature profile of weathering | Important stratigraphic marker |
| | | | | 500,000? | | |
| | Pre-Illinoian | KANSAN* (glacial) | | | Drift, loess | Glaciers from northeast and northwest covered much of state |
| | | | | 700,000? | | |
| | | AFTONIAN* (interglacial) | | | Soil, mature profile of weathering | (hypothetical) |
| | | | | 900,000? | | |
| | | NEBRASKAN* (glacial) | | | Drift (little known) | Glaciers from northwest invaded western Illinois |
| | | | | 1,600,000 or more | | |

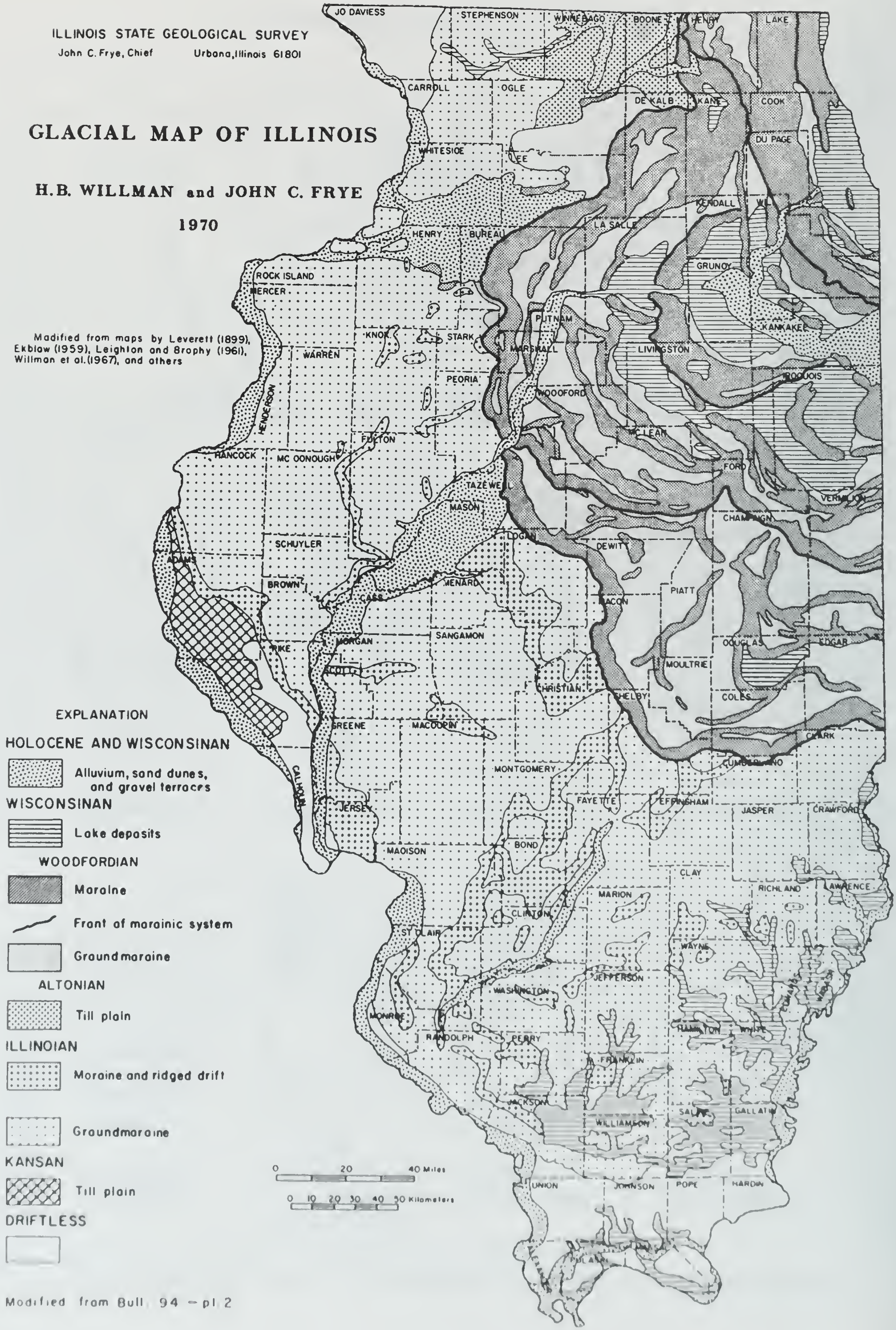
*Old oversimplified concepts, now known to represent a series of glacial cycles.

(Illinois State Geological Survey, 1973)

SEQUENCE OF GLACIATIONS AND INTERGLACIAL DRAINAGE IN ILLINOIS



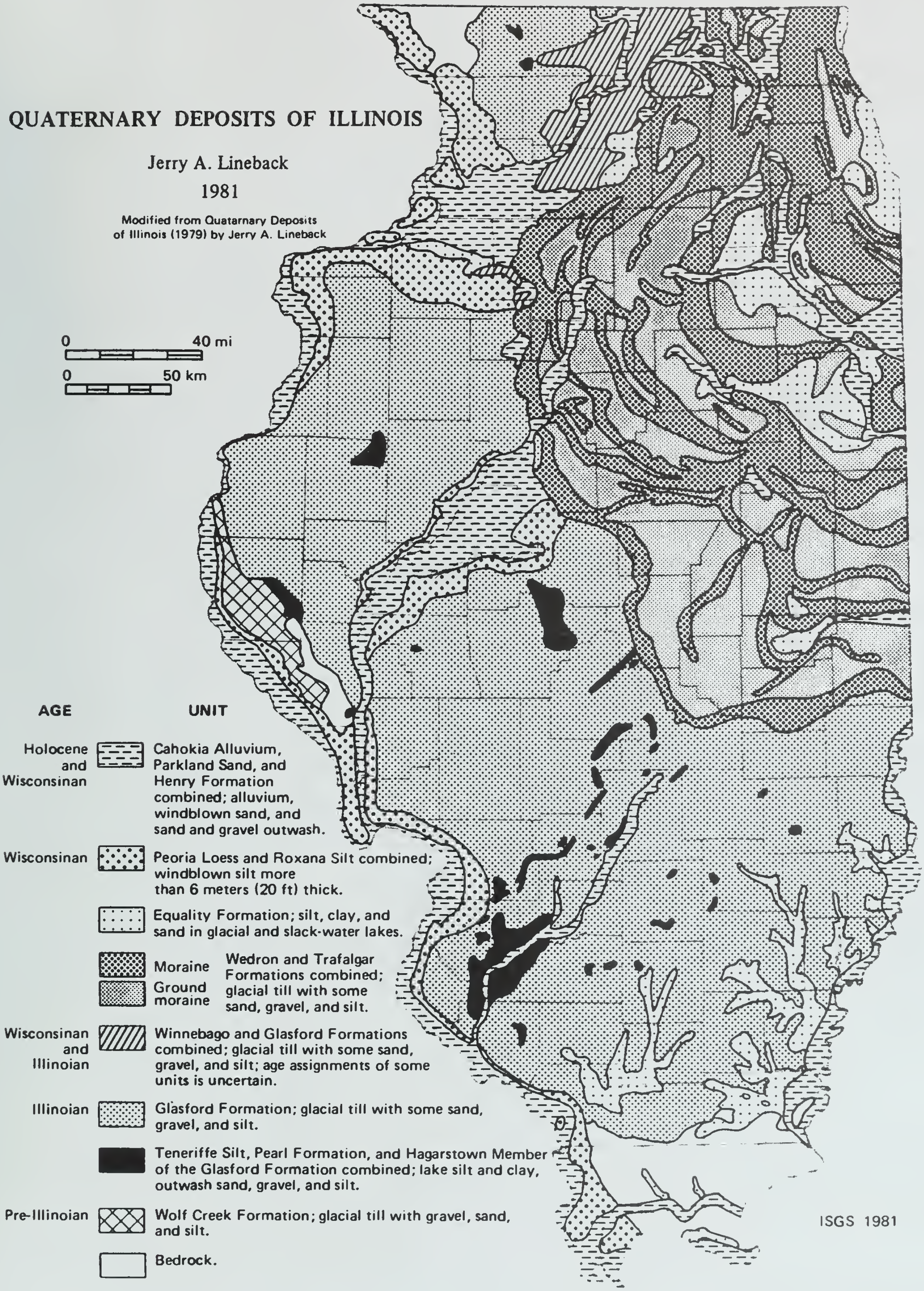

(Modified from Willman and Frye, "Pleistocene Stratigraphy of Illinois," ISGS Bull. 94, fig. 5, 1970.)

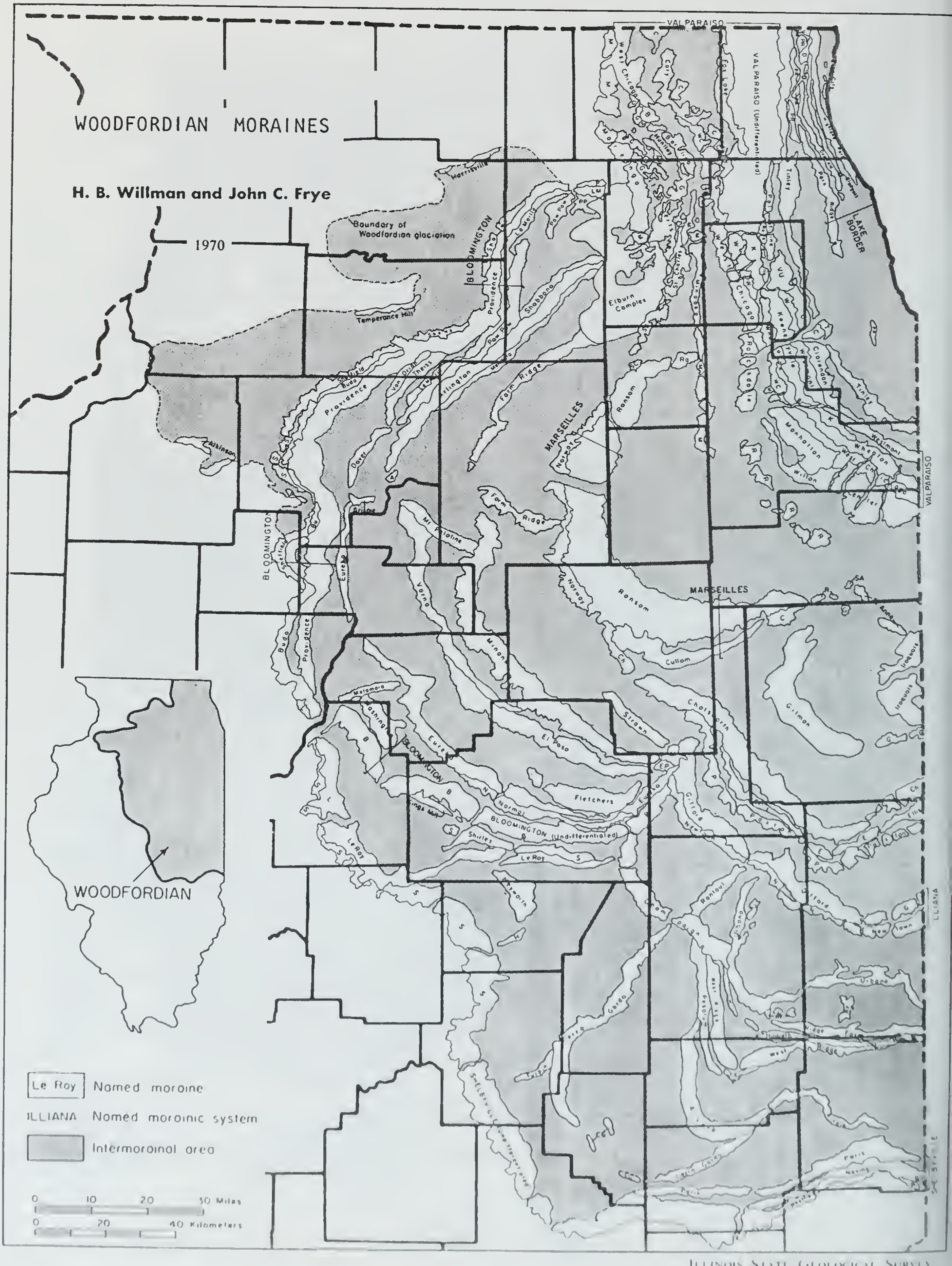

ILLINOIS STATE GEOLOGICAL SURVEY
John C. Frye, Chief
Urbana, Illinois 61801
GLACIAL MAP OF ILLINOIS
H.B. WILLMAN and JOHN C. FRYE
1970
Modified from maps by Leverett (1899), Ekblaw (1959), Leighton and Brophy (1961), Willman et al. (1967), and others
EXPLANATION
HOLOCENE AND WISCONSINAN
Alluvium, sand dunes, and gravel terraces
WISCONSINAN
Lake deposits
WOODFORDIAN
Moraine
Front of morainic system
Groundmoraine
ALTONIAN
Till plain
ILLINOIAN
Moraine and ridged drift
Groundmoraine
KANSAN
Till plain
DRIFTLESS
0 20 40 Miles
0 10 20 30 40 50 Kilometers
JO DAVIESS
STEPHENSON
WINNEBAGO
BOONE
LAKE
CARROLL
OGLE
DE KALB
KANE
COOK
DU PAGE
WHITESIDE
LEE
KENDALL
LA SALLE
HENRY
BUREAU
GRUNDY
ROCK ISLAND
MERCER
PUTNAM
KANKAKEE
KNOX
STARK
MARSHALL
LIVINGSTON
WARREN
PEORIA
IROQUOIS
HENDERSON
WOODFORD
MC LEAN
FULTON
HANCOCK
MC DONOUGH
FORD
TAZEWELL
MASON
VERMILION
CHAMPAIGN
SCHUYLER
LOGAN
DEWITT
ADAMS
BROWN
CASS
MENARD
PIATT
MACON
PIKE
MORGAN
SANGAMON
DOUGLAS
EDGAR
SCOTT
CHRISTIAN
MOULTRIE
SHELBY
COLES
GREENE
MACOUPIN
CLARK
CUMBERLAND
MONTGOMERY
CALHOUN
JERSEY
FAYETTE
EFFINGHAM
JASPER
CRAWFORD
BOND
MADISON
CLAY
MARION
RICHLAND
LAWRENCE
CLINTON
ST CLAIR
WAYNE
WASHINGTON
JEFFERSON
MONROE
RANDOLPH
PERRY
HAMILTON
WHITE
FRANKLIN
JACKSON
WILLIAMSON
SALINE
GALLATIN
UNION
JOHNSON
POPE
HARDIN
PULASKI
Modified from Bull. 94 – pl. 2

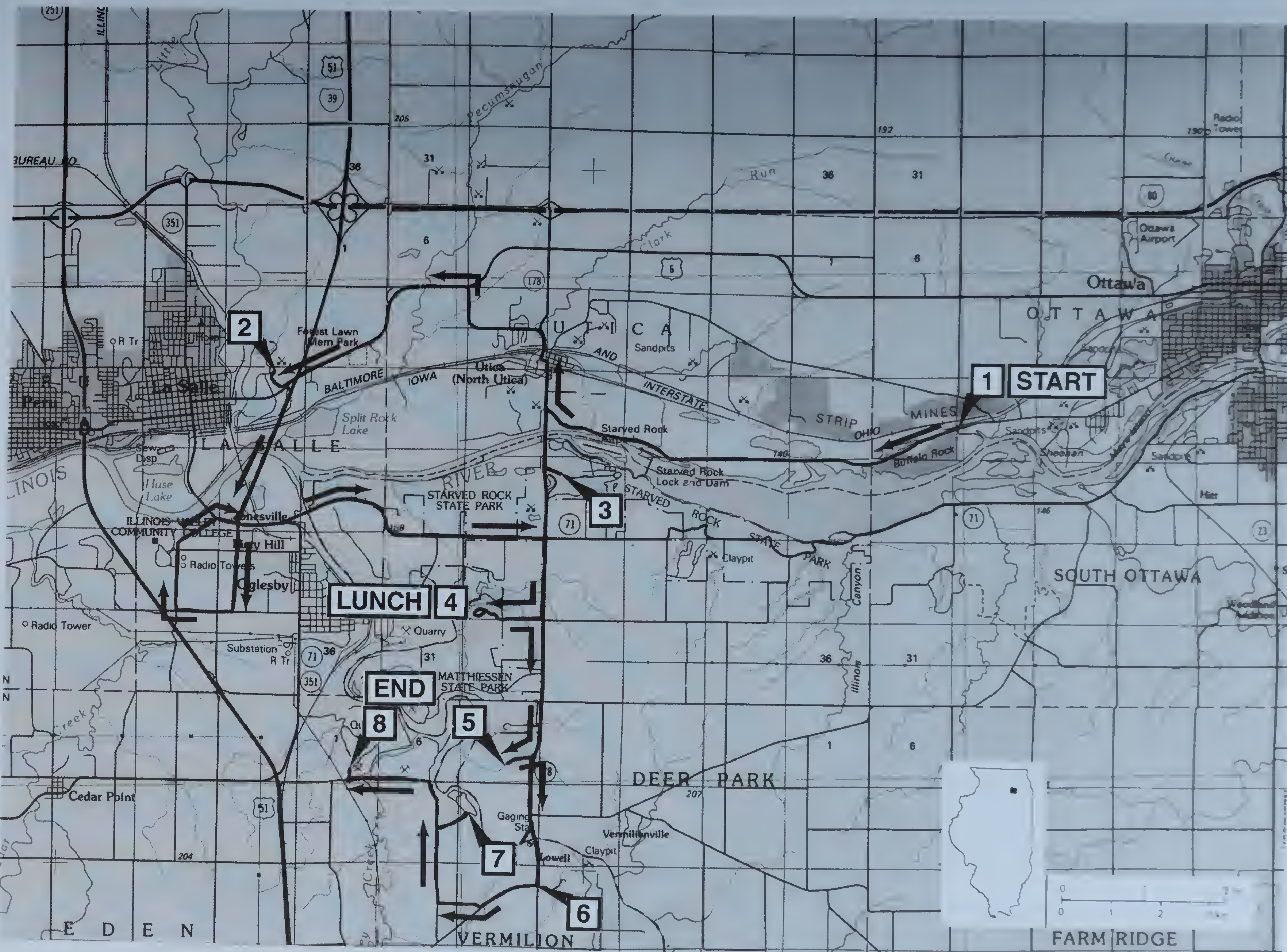
# QUATERNARY DEPOSITS OF ILLINOIS

Jerry A. Lineback
1981

Modified from Quaternary Deposits of Illinois (1979) by Jerry A. Lineback




WOODFORDIAN MORAINES
H. B. Willman and John C. Frye
1970
Boundary of Woodfordian glaciation
BLOOMINGTON
MARSEILLES
VALPARAISO
VALPARAISO (Undifferentiated)
LAKE BORDER
ILLIANA
BLOOMINGTON (Undifferentiated)
Elburn Complex
Temperance Hill
Harrisville
Providence
Shabbona
Farm Ridge
Ransom
Cullom
Chatsworth
Gilman
Fletchers
Normal
Shirley
Le Roy
El Paso
Eureka
Metamora
Atkinson
Minonk
Varna
Mt Palatine
Manhattan
Wilton
Westmont
Wheaton
Clarendon
Tinley
Urbana
WOODFORDIAN
Le Roy Named moraine
ILLIANA Named morainic system
Intermorainal area
0 10 20 30 Miles
0 20 40 Kilometers


START
LUNCH
END
1
2
3
4
5
6
7
8
Ottawa
OTTAWA
SOUTH OTTAWA
UTICA
Utica (North Utica)
La Salle
Peru
LA SALLE
Oglesby
Jonesville
ILLINOIS VALLEY COMMUNITY COLLEGE
Radio Towers
Radio Tower
Substation
Cedar Point
EDEN
DEER PARK
VERMILION
FARM RIDGE
BUREAU CO
Forest Lawn Mem Park
BALTIMORE IOWA AND INTERSTATE
OHIO STRIP MINES
Split Rock Lake
Huse Lake
ILLINOIS RIVER
STARVED ROCK STATE PARK
Starved Rock Lock and Dam
Starved Rock Airport
Buffalo Rock
Sheehan
Sandpits
Claypit
Quarry
MATTHIESSEN STATE PARK
Gaging Sta
Lowell
Vermilionville
Canyon
Pecumsaugan
Clark Run
Ottawa Airport
Radio Tower